DEVICE FOR ASSISTING SHOULDER REHABILITATION OR EXERCISE

Technical Field

The present disclosure relates generally to apparatuses or devices for shoulder rehabilitation or exercise.

Background

The shoulder joint is a multi-axial ball-and-socket joint that is the most mobile joint in the body. Various types of shoulder joint conditions or injury exist. For instance, common shoulder joint conditions can correspond to frozen shoulders, tendinitis, fractures, hemiplegic shoulders, rotator cuff injury, and bankart lesions. With respect to the rehabilitation of shoulder joint conditions or injuries, in addition to manual joint and soft tissue mobilization, physiotherapists give patients exercises to help them regain or restore joint mobility, muscle strength, and function. For rehabilitating several types of shoulder joint conditions or injury, patients can require 4-8 sessions of physiotherapy each week over a time period of 6-12 weeks.

Depending on the type and extent of patient injury as well as the current level of patient rehabilitation, shoulder rehabilitation exercises typically progress in incremental stages. Rehabilitation typically starts with a passive motion exercise stage, and subsequently progresses to an active-assisted motion exercise stage, and further progresses to an active motion exercise stage. From one rehabilitation stage to another, the patient needs to apply greater physical effort to get their shoulder joint moving and their muscles working properly.

Passive motion exercises are movements performed upon a patient by an external force. Passive motion exercises can be carried out by a passive motion machine, a therapist, or in some cases patients themselves. As the patient's recovery from their condition or injury progresses, active-assisted exercises are performed to progressively activate and strengthen muscles. Active-assisted exercises are exercises performed by the patient with the help of an external support or force. Some active-assisted exercises are exercises

performed with an overhead pulley-and-rope system, for instance, using a bar or the patient's unimpaired hand. Finally, active exercises are exercises done independently by the patient against a resistance such as the weight of patient's own upper limb, gravity, or resistance provided by elastic bands or free weights.

Devices currently exist for passively moving the shoulder joint and strengthening the shoulder muscles. An active-assisted shoulder rehabilitation or exercise device also exists, as described in U.S. Patent No. 8,251,879. This shoulder rehabilitation device relies upon a hydraulic mechanism that specifically facilitates patient performance of internal and external shoulder rotation. Unfortunately, the hydraulic mechanism in this shoulder rehabilitation device is unnecessarily complex and costly, and this shoulder rehabilitation device fails to facilitate or provide for a sufficiently diverse range of patient movement types other than internal and external shoulder rotation which could enhance the efficacy of shoulder rehabilitation.

A need exists for a simpler active-assisted shoulder rehabilitation device that provides additional types of shoulder rehabilitation movements for enhancing shoulder rehabilitation efficacy.

Summary

In accordance with an aspect of the disclosure, a shoulder rehabilitation and/or exercise device includes: a base plate having an inner border and an outer border, the base plate providing an outer surface having a planar surface area between the inner border and the outer border; a pivot element coupled to the base plate, the pivot element defining a pivot axis perpendicular to the outer surface of the base plate; an elongate rail structure disposed adjacent to the base plate and coupled to the pivot element in a manner that enables clockwise and counterclockwise rotation of the elongate rail structure relative to the pivot axis, the elongate rail structure having a first end proximate to the pivot element, a second end that resides beyond the outer surface of the base plate, a length that extends along a rail axis between the first end and the second end of the elongate rail structure, and an outer surface along its length, the outer surface of the elongate rail

structure at least generally parallel to the outer surface of the base plate; a guide bar supported disposed above and extending parallel to the elongate rail structure, the guide bar having a predetermined length; a movable block slidably displaceable along a substantial portion of the length of the guide bar; a first set of adjustable magnetically attractive elements for selectively providing a first set of counter forces that oppose or act against linear displacement of the movable block parallel to the rail axis *r*; and a second set of adjustable magnetically attractive elements for selectively providing a second set of counter forces that oppose or act against rotational displacement of the movable block relative to the pivot axis *p*.

The shoulder rehabilitation and/or exercise device can further include a handle coupled to the movable block, the handle graspable by a user, the handle configured for communicating user forces to the movable block to selectively (a) displace the movable block parallel to the rail axis *r* and/or (b) rotate the movable block relative to the pivot axis *p*.

The first set of adjustable magnetically attractive elements can include: a magnetic material carried by the elongate rail structure; and a first set of magnets attachable to and detachable from the movable block, wherein each magnet within the first set of magnets when attached to the movable block exerts a magnetic attractive force upon the magnetic material carried by the elongate rail structure. The magnetic material carried by the elongate rail structure can form the outer surface of the elongate rail structure along at least substantial portions of the length of the elongate rail structure. The first set of magnets can include a plurality of magnets, each magnet within the first set of magnets when attached to the movable block providing a predetermined magnetic attractive force upon the magnetic material carried by the elongate rail structure.

The movable block can include a set of slots, each slot within the set of slots configured for removably receiving a magnet within the first set of magnets.

The second set of adjustable magnetically attractive elements can include: a magnetic material carried by the base plate; a first magnet holding structure coupled to the second end of the elongate rail structure and disposed near the pivot element; and a second set of magnets attachable to and detachable from the first magnet holding structure, wherein each magnet within the second set of magnets when carried by the first magnet holding structure exerts a magnetic attractive force upon the magnetic material carried by the base plate. The magnetic material carried by the base plate can form the outer surface of the base plate across at least a substantial portion of the planar surface area of the outer surface of the base plate. The second set of magnets can include a plurality of magnets, each magnet within the second set of magnets when held by the magnet holding structure providing a predetermined magnetic attractive force upon the magnetic material carried by the base plate.

The shoulder rehabilitation and/or exercise device can also include a second magnet holding structure disposed proximate to the pivot element; and a third set of magnets attachable to and detachable from the second magnet holding structure, wherein the third set of magnets when held by the second magnet holding structure provides (a) an attractive force with respect to the first set of adjustable magnetically attractive elements in a manner that opposes displacement of the movable block away from a bottom-most position along the guide rail, or (b) a repulsive force with respect to the first set of adjustable magnetically attractive elements in a manner that opposes displacement of the movable block toward the bottom-most position along the guide rail.

The base plate further includes a bottom surface disposed beneath the outer surface of the base plate, and the shoulder rehabilitation and/or exercise device can further include a stand structure having: a support arm coupled to the under surface of the base plate, an elevation bar coupled to the base plate, the elevation bar extending rearward behind the under surface of the base plate, the elevation bar configured for securely receiving the support arm at multiple support arm angles relative to the base plate for adjustable selection of a base plate angle of inclination relative to a planar surface of an object above which the base plate resides. The stand structure can further include at least one

clamp coupled to the elevation bar and the base plate; and/or a set of hinges by which the base plate and the elevation bar can be pivotally folded or opened relative to each other.

The shoulder rehabilitation and/or exercise device is configured to facilitate multiple categorical types of shoulder rehabilitation exercises or movements including each of shoulder flexion / extension, shoulder adduction / abduction, and shoulder internal / external rotation.

In accordance with an aspect of the present disclosure, a process for performing shoulder rehabilitation exercises or movements includes: providing a shoulder rehabilitation / exercise device having: a base plate having an inner border and an outer border, the base providing an outer surface having a planar surface area between the inner border and the outer border; a pivot element coupled to the base plate, the pivot element defining a pivot axis perpendicular to the outer surface of the base plate; an elongate rail structure disposed adjacent to the base plate and coupled to the pivot element in a manner that enables clockwise and counterclockwise rotation of the elongate rail structure relative to the pivot axis, the elongate rail structure having a first end proximate to the pivot element, a second end that resides beyond the outer surface of the base plate, a length that extends along a rail axis between the first end and the second end of the elongate rail structure, and an outer surface along its length, the outer surface of the elongate rail structure at least generally parallel to the outer surface of the base plate; a guide bar supported supported above and extending parallel to the elongate rail structure, the guide bar having a predetermined length; a movable block slidably displaceable along a substantial portion of the length of the guide bar; a first set of adjustable magnetically attractive elements for selectively providing a first set of counter forces that oppose or act against linear displacement of the movable block parallel to the rail axis *r*; a second set of adjustable magnetically attractive elements for selectively providing a second set of counter forces that oppose or act against rotational displacement of the movable block relative to the pivot axis *p*; and a handle coupled to the movable block, the handle configured for communicating user forces to the movable block to selectively (a) displace the movable block parallel to the rail axis *r* and/or (b) rotate the movable block relative to

the pivot axis *p*, the process including: establishing a level of the first set of counter force for opposing linear displacement of the movable block parallel to the rail axis *r* by way of adjustment of the first set of adjustable magnetically attractive elements; and establishing a level of the second set of counter forces for opposing rotational displacement of the movable block relative to the pivot axis *p* by way of adjustment of the second set of adjustable magnetically attractive elements. The process includes delivering user forces to the movable block by way of the handle to thereby (a) displace the movable block parallel to the rail axis *r*, and/or (b) rotate the movable block relative to the pivot axis *p*. The process can also include establishing an angle of inclination of the base plate relative to a planar surface of an object above which the base plate resides.

Brief Description of the Drawings

FIG. 1A is an isometric illustration of an active-assisted shoulder rehabilitation or exercise device in accordance with an embodiment of the present disclosure.

FIG. 1B is a schematic illustration showing portions of a representative base plate 100 according to an embodiment of the present disclosure.

FIG. 2 is a bottom plan view of the active-assisted shoulder rehabilitation or exercise device of FIG. 1A.

FIG. 3 is a front plan view of the active-assisted shoulder rehabilitation or exercise device of FIG. 1A.

FIG. 4 is a side view of the active-assisted shoulder rehabilitation or exercise device of FIG. 1A.

FIG. 5 is a schematic illustration showing a movable block that carries a first set of magnets, and which is displaceable along a guide bar of the active-assisted shoulder rehabilitation or exercise device of FIG. 1A in response to patient manipulation of a handle in accordance with an embodiment of the present disclosure.

FIG. 6A is a schematic illustration showing a magnet holding structure disposed proximate to a pivot element of the active-assisted shoulder rehabilitation or exercise device of FIG 1A in accordance with an embodiment of the present disclosure.

FIG. 6B and 6C illustrate an additional or auxiliary magnet holding structure disposed proximate to the pivot element of the active assisted shoulder rehabilitation or exercise device of FIG. 1A, in which magnets are absent and magnets are present, respectively, in accordance with an embodiment of the present disclosure.

Detailed Description

In the present disclosure, the use of "/" in a FIG. or associated text is understood to mean "and/or" unless otherwise indicated. The recitation of a particular numerical value or value range herein is understood to include or be a recitation of an approximate numerical value or value range (e.g., within +/- 20%, +/- 15%, +/- 10%, or +/- 5%).

As used herein, the term "set" corresponds to or is defined as a non-empty finite organization of elements that mathematically exhibits a cardinality of at least 1 (i.e., a set as defined herein can correspond to a unit, singlet, or single element set, or a multiple element set), in accordance with known mathematical definitions (for instance, in a manner corresponding to that described in *An Introduction to Mathematical Reasoning: Numbers, Sets, and Functions*, "Chapter 11: Properties of Finite Sets" (e.g., as indicated on p. 140), by Peter J. Eccles, Cambridge University Press (1998)). In general, an element of a set can include or be a system, an apparatus, a device, a structure, an object, a process, a physical parameter, or a value depending upon the type of set under consideration.

In the present disclosure, depiction of a given element or consideration or use of a particular element number in a particular FIG. or a reference thereto in corresponding descriptive material can encompass the same, an equivalent, or an analogous element or element number identified in another FIG. or descriptive material associated therewith.

FIGs. 1A – 6B provide schematic illustrations showing various portions of an apparatus or device 10 for active-assisted shoulder rehabilitation or exercise in accordance with an embodiment of the present disclosure. More particularly, FIG. 1A is an isometric illustration of an active-assisted shoulder rehabilitation or exercise device 10 in accordance with an embodiment of the present disclosure. FIG. 1B is a schematic illustration showing portions of a representative base plate 100 of the device 10 according to an embodiment of the present disclosure. FIG. 2 is a bottom plan view of the active-assisted shoulder rehabilitation or exercise device 10 of FIG. 1A. FIG. 3 is a front plan view of the active-assisted shoulder rehabilitation or exercise device 10 of FIG. 1A; and FIG. 4 is a side view of the active-assisted shoulder rehabilitation or exercise device 10 of FIG. 1A.

FIG. 5 is a schematic illustration showing a movable block 130 that carries a first set of magnets, and which is displaceable along a guide bar 120 of the active-assisted shoulder rehabilitation or exercise device 10 of FIG. 1A in response to patient manipulation of a handle 140 in accordance with an embodiment of the present disclosure. FIG. 6A is a schematic illustration showing a magnet holding structure 113 disposed proximate to a pivot element 200 of the active-assisted shoulder rehabilitation or exercise device 10 of FIG 1A in accordance with an embodiment of the present disclosure. FIG. 6B and 6C illustrate an additional or auxiliary magnet holding structure disposed proximate to the pivot element 200 of the active assisted shoulder rehabilitation or exercise device 10 of FIG. 1A, in which magnets are respectively absent and present, in accordance with an embodiment of the present disclosure.

With reference to FIG. 1A and other FIGs. provided herein, an apparatus or device 10 for active-assisted shoulder rehabilitation or exercise in accordance with an embodiment of the present disclosure includes a planar or generally planar base, main, or central plate 100 to which an elongate platform or rail structure 110 is pivotally coupled by way of a pivot mechanism or element 200 such as a fastener (e.g., a bolt or screw) or cylindrical projection (e.g., a cylindrical wedge or pin). The pivot element 200 secures the rail

structure 110 to the base plate 100 in a manner that enables the rail structure 110 to rotate or pivot in clockwise and counterclockwise directions relative to or across a first, outer, or top face or surface 101 of the base plate 100. The pivot element 200 thus defines a pivot point or pivot axis *p*. The pivot axis *p* extends perpendicular to the planar surface area of base plate 100, about which the rail structure 110 is displaceable in clockwise and counterclockwise directions.

The base plate 100 includes a first or inner border or edge 102 and a second or outer border or edge 104, which correspond to or define an extent of the base plate's planar surface area. In various embodiments, the base plate's outer edge 104 includes or has a curved or arcuate shape, for instance, such that portions of the base plate 100 beyond or away from its first or inner edge 102 exhibit an elliptical (e.g., circular) or generally elliptical shape (e.g., the base plate 100 exhibits a shape correlated with or corresponding to a truncated ellipse). In several embodiments, the base plate 100 can carry a set of stopping elements 106a-b, which can limit the pivotal extent of clockwise and counterclockwise motion of the rail structure 110 relative to the base plate's outer surface 101 (e.g., such that the overall extent of rail structure rotation across the outer surface 101 of the base plate 100 is limited to less than or equal to 180 degrees). The base plate 100 also includes an under surface 103 opposite to its outer surface 101 (e.g., the base plate's outer surface 101 and under surface 103 face in opposite directions, yet are parallel to each other).

FIG. 1B is a schematic illustration showing portions of a representative base plate 100 according to an embodiment of the present disclosure. In an embodiment, the base plate 100 has a maximum height *h* that can be defined parallel to or along a vertical axis *y*; a maximum width *w* that can be defined parallel to or along a horizontal axis x; and an origin or center point *O* that can be defined at an intersection of the vertical and horizontal axes, which can identify the center of a circle having a diameter that matches the base plate's width *w*. Depending upon embodiment details, in a number of embodiments the pivot element 200 can reside or be centered between approximately 20% - 33% of the distance between the base plate's inner edge 102 and this origin *O*.

With reference again to FIG. 1A, in various embodiments the rail structure 110 is centrally disposed relative to or defines a rail axis *r* that resides in a plane perpendicular to the pivot axis *p*. Thus, in such embodiments the rail axis *r* is perpendicular to the base plate's outer surface 101. The rail structure 110 includes a first end 112 and a second end 114 along its elongate length. The first end 112 of the rail structure 110 is disposed proximate or generally proximate to the pivot element 200, for instance, offset a relatively short distance away from the pivot element 200 toward the base plate's inner edge 102. The second end 114 of the rail structure is disposed beyond or significantly beyond the base plate's outer edge 104.

The rail structure 110 carries or supports an elongate guide bar or shaft 120, which is elevated a predetermined perpendicular distance away from an outer or top surface 111 of the rail structure 110 along a substantial portion of the rail structure's length. In some embodiments, the rail structure 110 carries a first housing or bar support element 116 disposed proximate to the pivot element 200 (e.g., offset slightly away from the pivot element 200 in a direction toward the rail structure's second end 114); and a second housing or bar support element 118 disposed proximate or adjacent to or essentially at the rail structure's second end 114. The guide bar 120 can be supported or held between the first and second bar support elements 116, 118 at a given distance away from the rail structure's outer surface 111.

A movable block 130 is coupled to the guide bar 120 in a manner that enables slidable displacement or translation of the movable block 130 along substantially the entire length of the guide bar 120. For instance, the movable block 130 can include a slide element 132 such as a linear bearing configured for receiving or surrounding a given fraction of the guide bar's length, which enables smooth bidirectional linear motion of the movable block 130 along the guide bar 120, or equivalently, along or parallel to the rail axis *r*.

The movable block 130 carries a handle 140 that a patient, subject, or user of the device 10 can grasp and apply forces to in order to perform or attempt to perform multiple

categorical types of shoulder rehabilitation movements or exercises. More particularly, in response to a patient force applied to the handle 140 in a direction parallel to or along the guide bar's length, or equivalently parallel to the rail axis *r*, the movable block 130 correspondingly travels along portions of the length of the guide bar 120 or along the rail axis *r* in the direction of the applied patient force. Thus, in response to a patient force applied to the handle 140 in a direction along the guide bar's length / parallel to the rail axis *r*, the movable block 130 is displaced along the guide bar's length / parallel to the rail axis *r*, toward or away from the pivot element 200, and is radially displaced toward or away from the base plate's center point or origin *O*. Identical considerations apply to a patient force applied to the handle 140 having a vector force component parallel to the guide bar's length / the rail axis *r*; such a vector force component parallel to the guide bar's length / the rail axis *r* results in displacement of the movable block 130 along the guide bar 120 in the direction of this vector force component.

In addition to the foregoing, in response to a patient force applied to the handle 140 in a rotational direction, or a direction transverse or perpendicular to the guide bar's length / the rail axis *r*, the movable block 130, the guide bar 120, and the rail structure 110 are collectively displaced in a clockwise or counterclockwise direction relative to the base plate's outer surface 101. Hence, in response to a patient force upon the handle 140 that includes a vector component along or parallel to the base plate's horizontal axis *x*, which can be defined as a rotational force applied or delivered to the movable block 130 by way of the handle 140, the movable block 130, the guide bar 120, and the rail structure 110 collectively rotate or pivot about the pivot axis *p* in a clockwise or counterclockwise direction in accordance with the direction of the applied rotational force.

In view of the foregoing, a patient can apply forces to the handle 140 in order to (a) linearly displace the movable block 130 back and forth or up and down along the rail axis *r*; and/or (b) rotatably displace the movable block 130, the guide bar 120, and the rail structure 110 about the pivot axis *p*. An individual having ordinary skill in the relevant art will recognize that with respect to linear displacement of the moveable block 130 parallel to the rail axis *r* by way of the handle 140, the handle 140, the movable block

130, the guide bar 120, and the rail structure 110 provide a flexion / extension section of the device 10 that facilitates or enables flexion / extension motions or exercises. An individual having ordinary skill in the relevant art will also recognize that with respect to rotational or pivotal displacement of the moveable block 130 in clockwise or counterclockwise directions relative to the pivot axis *p* by way of patient forces applied to the handle 140, the handle 140, the movable block 130, the guide bar 120, the rail structure 110, the pivot element 200, and the base plate 100 provide an adduction / abduction section of the device 10, which facilitates or enables adduction / abduction motions or exercises.

In several embodiments, the handle 140 includes a grip portion having a set of ball bearings coupled or connected to an elongated section of the handle 140, such that the handle grip can rotate in accordance with the patient's wrist motion. In certain embodiments, the handle 140 can be coupled or attached to the movable block 130 such that it projects or extends away from the movable block 130 in accordance with predetermined angles, such that the handle 140 extends perpendicular to an upper surface of the movable block 130 in a direction parallel to the pivot axis *p*; or at one or more predetermined angles of about the rail axis *r* relative to the pivot axis *p*.

The flexion / extension section of the device 10 includes a first set of adjustable or removable magnetically attractive elements for selectively / selectably providing constant friction or counter forces that can oppose or act against linear displacement of the movable block 130 along the guide bar 120 / parallel to the rail axis *r*. The adduction / abduction section of the device 10 includes a second set of adjustable or removable magnetically attractive elements for selectively / selectably providing constant friction or counter forces that can oppose or act against rotational displacement of the movable block 130 relative to the pivot axis *p*. More specifically, in various embodiments the device 10 includes a first set of adjustable / removable magnets and a first magnetic surface for selectively / selectably providing constant friction / counter forces that can oppose or act against linear displacement of the movable block 130 along the elongate guide bar 120 / parallel to the rail axis *r*; and at least a second set of adjustable /

removable magnets and a second magnetic surface for selectively / selectably providing constant friction / counter forces that can oppose or act against rotational displacement of the movable block 130 relative to the pivot axis *p*.

For instance, with respect to the flexion / extension section of the device 10 and the first set of adjustable magnetically attractive elements, in multiple embodiments the rail structure 110 carries or includes a magnetic material, such as a thin or relatively thin outer layer, sheet, or coating of steel that forms the rail structure's outer surface 111; and the movable block 130 can carry or hold a first set of magnets 300. In a number of embodiments, the first set of magnets 300 includes at least a first magnet 300a, and typically includes a second through a fourth magnet 300b-d, each of which is selectively / selectably insertable into and removable from the movable block 130, and hence magnetically attachable to and detachable from the rail structure 110. In other embodiments, the first set of magnets 300 can include more individual magnets (e.g., six or eight magnets). A given individual magnet 300a-d within the first set of magnets 300 can be inserted into and removed from the movable block 130 by way of respective insertion into and removal from a corresponding slot, cutout, recess, or channel formed in a lower or inner region, portion, or surface of the movable block 130 that is proximate to the rail structure's outer surface 111. In a number of embodiments, left and right lock pins 134 retain a predetermined number of individual magnets 300a-b, 300c-d on left and right sides of the movable block 130, respectively, on either side of the guide rail 120. Each of the individual magnets 300a-d can be a conventional permanent magnet, and can be made using a commercially available ferromagnetic material, in a manner readily understood by one having ordinary skill in the relevant art.

When magnets 300a-d are absent from the movable block 130 (i.e., no magnets 300a-d are carried by the movable block 130), the mass of the movable block 130 in conjunction with typically small (or very small) friction forces inherently associated with motion of the movable block 130 along the guide bar 120 by way of the linear bearing 132 determine a minimum amount of force that a patient must apply to the handle 140 in a direction parallel to the guide bar 120 to displace the movable block 130 therealong.

When the movable block 130 carries one or more magnets 300a-d, each magnet 300a-d magnetically adheres to the rail structure's magnetic material and thereby applies a constant magnetic force that acts to oppose or counter displacement of the movable block 130 along the guide bar 120. For instance, this magnetic force is directed from each magnet 300a-d toward the rail structure's outer surface 111, and adheres the magnet 300a-d against the outer surface 111 of the rail structure 110. The magnetic force of each magnet 300a-d that is present must be overcome in order to displace the movable block 130 along the guide bar 120. Thus, with an increasing number of magnets 300a-d carried by the movable block 130, displacement of the movable block 130 becomes progressively more difficult for the patient, up to a maximum level or degree difficulty when the movable block 130 carries each magnet 300a-d within the first set of magnets 300.

In various embodiments, each magnet 300a-d within the first set of magnets 300 provides or exerts a predetermined magnetic attractive force toward or upon the outer surface 111 of the rail structure 110, for instance, approximately 0.5 kg of force in a representative nonlimiting implementation. When the first set of magnets 300 includes a total of four individual magnets 300a-d, the patient or a therapist can therefore selectably insert 1, 2, 3, or 4 magnets into the movable block 130, such that the overall magnetic attractive force that the patient must overcome to displace the movable block 130 along the guide rail 120 is approximately 0.5, 1.0, 1.5, and 2.0 kg, respectively. The movable block 130 can include at least one slot or a set of slots, each slot within the set of slots configured for receiving a magnet within the first set of magnets. As will be recognized by one having ordinary skill in the relevant art, when a patient initially attempts shoulder rehabilitation exercises, no magnets, or 1 or perhaps 2 magnets 300a,c depending upon the state of the patient's shoulder, would typically be inserted into the movable block 130. As the patient's shoulder rehabilitation progresses or improves and the patient's shoulder muscles become stronger, additional magnets 300b,d can be inserted into the movable block 130. Additionally or alternatively, the magnetic strength of individual magnets 300a-d within the first set of magnets 300 can be increased as the patient's rehabilitation progresses.

With respect to the adduction / abduction section of the device 10 and the second set of adjustable magnetically attractive elements, in multiple embodiments the base plate 100 carries or includes a magnetic material, such as a layer, sheet, or coating of steel that forms the base plate's outer surface 111; and the rail structure 110 carries a second set of magnets 400 near, proximate, or adjacent to its first end 112, each of which is selectably / selectably insertable into and removable from the rail structure 110, and hence magnetically attachable to and detachable from the base plate 100. In a number of embodiments, the rail structure 110 includes or provides at least a first or primary magnet carrying portion or holding structure 113 proximate to the pivot element 200, which includes a set of magnet receptacles for carrying the second set of magnets 400. In a representative embodiment, the second set of magnets 400 includes at least a first magnet 400 and typically a second through a fourth magnet 400b-d, each of which is selectively / selectably insertable into and removable from a first through a fourth magnet receptacle 124a-d. In other embodiments, the second set of magnets 400 can include additional individual magnets (e.g., six or eight magnets).

When no magnets 400a-d are carried by the magnet holding structure 113 (i.e., no magnets 400a-d reside within the magnet receptacles), the masses of the rail structure 110, the guide bar 120, the movable block 130, and the handle 140 in conjunction with the friction forces present where the rail structure 110 interfaces with the base plate 100, as well as moment arms defined by the longitudinal distance that the center of mass of the movable block 130 resides from the pivot axis *p*, and the distance that the center of mass of the magnet holding structure resides away from the pivot axis *p* in accordance with the principle of moments, determine a minimum amount of rotational force that the patient must apply to the handle 140 (e.g., force having a vector component parallel to the base plate's horizontal axis *x*) to rotate the adduction / abduction section of the device 10 about the pivot axis *p*.

When the magnet receptacles carry one or more magnets 400a-d, each magnet 400a-d magnetically adheres to the base plate's magnetic material and thereby applies a constant

magnetic force that acts to oppose or counter rotational or pivotal displacement of the adduction / abduction section about the pivot axis *p*. That is, each magnet 400a-d exerts a magnetic force toward the outer surface 101 of the base plate 100, which adheres the magnet to the base plate's outer surface 101. For each magnet 400a-d present, this magnetic force must be overcome in order to pivotally displace the adduction / abduction section relative to the pivot axis *p*. Thus, with an increasing number of magnets 400a-d carried by the set of magnet receptacles, rotational displacement of the adduction / abduction section about the pivot axis p becomes progressively more difficult for the patient, up to a maximum level or degree of difficulty when the set of magnet receptacles carries each magnet 400a-d within the second set of magnets 400.

In various embodiments, each magnet 400a-d within the second set of magnets 400 provides or exerts a predetermined magnetic attractive force toward or upon the base plate's outer surface 101, for instance, approximately 0.5 kg of force in a representative nonlimiting implementation. When the second set of magnets 400 includes a total of four individual magnets 400a-d, the patient or a therapist can therefore selectably insert 1, 2, 3, or 4 magnets into the set of magnet receptacles to provide increasing levels of magnetic force, such as approximately 0.5, 1.0, 1.5, and 2.0 kg of force, that the patient must overcome to rotate the adductor / abductor section relative to the pivot axis *p*. The principle of moments indicates that if an object is balanced about a pivot axis *p*, then the sum of clockwise moments equals the sum of counterclockwise moments. Thus, in accordance with a force times distance definition of a moment arm, the rotational force applied by the patient to the movable block 130 times the distance between the movable block's center of mass and the pivot axis *p* must exceed the magnetic attractive force provided by a selected number of magnets 400a-d carried by the set of magnet receptacles times the distance between the center of mass of such magnets 400a-d and the pivot axis *p*.

As will be recognized by one having ordinary skill in the relevant art, when a patient initially attempts shoulder rehabilitation exercises, no magnets, or 1 or perhaps 2 magnets 400a,d depending upon the state of the patient's shoulder, would typically be inserted

into the set of magnet receptacles. As the patient's shoulder rehabilitation progresses and the patient's shoulder muscles become stronger, additional magnets 400b,c can be inserted into the set of magnet receptacles. Additionally or alternatively, the magnetic strength of individual magnets 400a-d within the second set of magnets 400 can be increased as the patient's rehabilitation progresses.

In some embodiments, such as shown in FIGs. 6A and 6B, the rail structure 110 includes an additional, auxiliary, or second magnet holding structure 115 having additional or auxiliary magnet receptacles into which an additional or third set of magnets 500 can be selectively / selectably inserted. In the embodiment shown, the third set of magnets 500 includes at least a first magnet 500a, and typically a second magnet 500b; and the additional / auxiliary magnet holding structure 115 thus includes a first and a second additional / auxiliary magnet receptacle for receiving the first and the second magnet 500a-b. In other embodiments, the third set of magnets can correspondingly include another number of magnets 500, and the additional / auxiliary magnet holding structure can correspondingly provide another number of additional / auxiliary magnet receptacles.

When the movable block 130 is disposed at or proximate to a bottom-most position along the guide rail 120 closest to the pivot element 200, one or more magnetic fields produced by each magnet 500a-b inserted into the additional / auxiliary magnet receptacles can interact with one or more magnetic fields proceed by each magnet 300a-d inserted into the movable block 130, in a manner that either (a) acts against displacement of the movable block 130 away from its bottom-most position along the guide rail 120 as a result of magnetic attraction (e.g., as a result of an appropriate positive-to-negative magnetic pole orientation between the first set of magnets 300 and the third set of magnets 500); or (b) acts against displacement of the movable block 130 toward its bottom-most position along the guide rail 120 as a result of magnetic repulsion (e.g., as a result of an appropriate positive-to-positive or negative-to-negative magnetic pole orientation between the first set of magnets 300 and the third set of magnets 500). When the first set of magnets 300 and the third set of magnets 500 are configured to act against displacement of the movable block 130 away from its bottom-most position along the

guide rail 120, the patient needs to exert counteracting forces to move the handle 140 and the movable block 130 away from its bottom-most position. When the first set of magnets 300 and the third set of magnets 500 are configured to act against displacement of the movable block 130 toward its bottom-most position along the guide rail 120, the patient needs to exert counteracting forces to move the handle toward and to its bottom-most position. A given level or amount of magnetic force that a user must exert or overcome to displaceable block 130 toward its bottom-most position or away from its bottom-most position can be adjusted or varied by adding or removing individual magnets 500a,b from the additional / auxiliary magnet receptacles.

The shoulder rehabilitation or exercise device 10 can in some embodiments further include a stand structure 600 by which the device 10 can be mounted or attached to a table, desk, bench, counter, platform, or object providing a planar or generally planar surface upon or above which the base plate 100 can reside. In various embodiments, the stand structure 600 includes a first lateral support element 602 coupled to the base plate 100, for instance, parallel to or along the base plate's inner edge 102; a second lateral support element 604 that is disposed parallel to the first lateral support element 602, and which is pivotally coupled to the first lateral support element 602 by way of a set of hinges 606a,b; a profiled or notched elevation bar 610 that extends perpendicular to the second lateral support element 604 in a rearward direction, beneath and behind an under or bottom surface of the base plate 100; and at least one clamp element (e.g., at least one conventional type of C-clamp or G-clamp, such as left and right C-clamps or G-clamps) 620 by which the second lateral support element 604 can be secured to the table, desk, bench, counter, or platform. The clamp element 620 includes a rotatable screw 622 by which the clamp element and hence the second lateral support element 604 can be securely mounted to the table, desk, bench, counter, or platform, in a manner readily understood by one having ordinary skill in the relevant art.

As indicated in FIG. 4, the stand structure 600 additionally includes a support arm 630 that is coupled to the under or bottom side of the base plate 100, for instance, at, near, or generally near a location corresponding to the base plate's center or origin *O*. The

support arm 630 includes a terminal end 632 that can be selectively / selectably retained at one or more predetermined positions along the elevation bar 610 such that the base plate 100 can be maintained at a predetermined angle of inclination relative to the elevation bar 610, and hence relative to the surface of a table, desk, bench, counter, or platform, or object above which the base plate 100 resides, or to or upon which the device 10 is mounted. In various embodiments, the elevation bar 610 includes a number of notches, recesses, or indentations 612 configured for (a) receiving and securely retaining the terminal end 632 of the support arm 630, and (b) providing the base plate 100 with particular predetermined angles of inclination relative to the elevation bar 610 and hence the surface relative to which the device 10 is mounted. In a representative implementation, the elevation bar 610 includes notches 612 by which the angle of inclination of the base plate 100 can be selected between approximately 10 degrees and 80 degrees, in 10 degree increments. The elevation bar 610 can also include a terminal block 614 that limits the travel of the support arm 630 to a maximum predetermined distance along the elevation bar 610. In an alternative embodiment, the support arm 630 can be collapsible, in a manner that represents a collapsible type of stick antennae adapted to elongate or shorten in length, whereby the angle of inclination of the base plate 100 can be selected in a manner correlated with simple trigonometry.

As a result of the set of hinges 606a,b, the device is foldable; that is, the hinges 606a,b enable pivotal motion of the base plate 100 and the elevation bar 610 relative to each other for folding / closing or opening / expanding the device 10. Furthermore, the entire device 10 can be lightweight and portable (e.g., packed into and transported by way of a single bag or carrier). To facilitate lightweight construction, portions of the base plate 100 and/or the rail structure 110 can include one or more types of lightweight polymers, which carry a layer of magnetic material to facilitate magnetic attraction to the first and possibly a third set of magnets 400, 500 as described above, such that the forces that patients must exert in order to perform rehabilitation exercises or movements can be easily adjusted or tailored in accordance with the physical state of their shoulder and their rehabilitation stage or progress. Devices 10 in accordance with embodiments of the present disclosure exhibit a simple, low cost, and reliable / robust structure that

effectively aids patient performance of multiple categorical types of shoulder rehabilitation exercises or movements.

In view of the foregoing, one having ordinary skill in the art will recognize that while a shoulder rehabilitation or exercise device 10 in accordance with an embodiment of the present disclosure can facilitate patient performance of internal and external rotation movements / exercises (e.g., such as when the patient is directly facing the base plate 100, and the patient applies rotational forces to the handle 140 to rotate the movable block 130 clockwise and counterclockwise relative to the pivot axis *p*), such a device is not limited to facilitating patient performance of internal and external rotation movements / exercises. As one having ordinary skill in the relevant art will recognize, a shoulder rehabilitation or exercise device 10 in accordance with an embodiment of the present disclosure can additionally facilitate patient performance of exercises or movements corresponding to shoulder flexion and extension (e.g., when the patient is directly facing the base plate 100, and the patient applies forces to the handle 140 linearly displace the movable block 130 along portions of the guide rail's length); and adduction and abduction (e.g., when the patient is positioned to one side of the base plate 100, and the patient uses the handle 140 to raise or lower the movable block along portions of the guide rail's length). Thus, a shoulder rehabilitation / exercise device 10 in accordance with various embodiments of the present disclosure is configured for facilitating each of shoulder internal / external rotation; shoulder flexion / extension; and shoulder adduction / abduction. Furthermore, shoulder exercises or movements can be performed through various spatial planes in accordance with selected / selectable orientations of the device 10 resulting from adjustment of an angle of inclination of the base plate 100 relative to a surface above which the base plate 100 resides or is mounted (e.g., to establish a particular base plate angle of inclination relative to the surface above which the base plate 100 resides, such as a particular angle of vertical base plate inclination between approximately 5 degrees – 85 degrees, 10 degrees – 80 degrees, or another angular range), and patient application of forces to the handle 140 to displace the handle 140 and the movable block 130 relative to the rail structure axis *r* and/or the pivot axis *p*. In various embodiments, the flexion / extension section facilitates patient performance of

flexion / extension exercises or motions while the patient is facing the device 10 (e.g., while the patient, subject, or user is facing the base plate 100).

One having ordinary skill in the art will recognize that one or more dimensions and/or shape characteristics of various portions of a shoulder rehabilitation and exercise device 10 (e.g., the height *h* and width *w* of the base plate 100, the overall length of the rail structure110, and/or the length / width of the movable block 130) in accordance with any given embodiment of the present disclosure can be selected or determined based upon various factors, including one or more of patient characteristics (e.g., adult patients versus juvenile patients); a number of first, second, and/or third sets of magnets 300, 400, 500 that the device 10 is configured for carrying; and the maximum magnetic forces exertable by the first, second, and/or third sets of magnets 300, 400, 500.

Aspects of particular embodiments of the present disclosure address at least one aspect, problem, limitation, and/or disadvantage associated with exiting active-assisted shoulder rehabilitation or exercise apparatuses or devices. While features, aspects, and/or advantages associated with certain embodiments have been described in the disclosure, other embodiments may also exhibit such features, aspects, and/or advantages, and not all embodiments need necessarily exhibit such features, aspects, and/or advantages to fall within the scope of the disclosure. It will be appreciated by a person of ordinary skill in the art that several of the above-disclosed systems, components, processes, or alternatives thereof, may be desirably combined into other different systems, components, processes, and/or applications. In addition, various modifications, alterations, and/or improvements may be made to various embodiments that are disclosed by a person of ordinary skill in the art within the scope of the present disclosure.

Claims

1. A shoulder rehabilitation and/or exercise device, comprising:

a base plate having an inner border and an outer border, the base plate providing an outer surface having a planar surface area between the inner border and the outer border;

a pivot element coupled to the base plate, the pivot element defining a pivot axis perpendicular to the outer surface of the base plate;

an elongate rail structure disposed adjacent to the base plate and coupled to the pivot element in a manner that enables clockwise and counterclockwise rotation of the elongate rail structure relative to the pivot axis, the elongate rail structure having a first end proximate to the pivot element, a second end that resides beyond the outer surface of the base plate, a length that extends along a rail axis between the first end and the second end of the elongate rail structure, and an outer surface along its length, the outer surface of the elongate rail structure at least generally parallel to the outer surface of the base plate;

a guide bar supported disposed above and extending parallel to the elongate rail structure, the guide bar having a predetermined length;

a movable block slidably displaceable along a substantial portion of the length of the guide bar;

a first set of adjustable magnetically attractive elements for selectively providing a first set of counter forces that oppose or act against linear displacement of the movable block parallel to the rail axis *r*; and

a second set of adjustable magnetically attractive elements for selectively providing a second set of counter forces that oppose or act against rotational displacement of the movable block relative to the pivot axis *p*.

2. The shoulder rehabilitation and/or exercise device of claim 1, further comprising a handle coupled to the movable block, the handle graspable by a user, the handle configured for communicating user forces to the movable block to selectively (a) displace the movable block parallel to the rail axis *r* and/or (b) rotate the movable block relative to the pivot axis *p*.

3. The shoulder rehabilitation and/or exercise device of claim 1, wherein the first set of adjustable magnetically attractive elements comprises:

a magnetic material carried by the elongate rail structure; and

a first set of magnets attachable to and detachable from the movable block,

wherein each magnet within the first set of magnets when attached to the movable block exerts a magnetic attractive force upon the magnetic material carried by the elongate rail structure.

4. The shoulder rehabilitation and/or exercise device of claim 3, wherein the magnetic material carried by the elongate rail structure forms the outer surface of the elongate rail structure along at least substantial portions of the length of the elongate rail structure.

5. The shoulder rehabilitation and/or exercise device of claim 3, wherein the first set of magnets includes a plurality of magnets, each magnet within the first set of magnets when attached to the movable block providing a predetermined magnetic attractive force upon the magnetic material carried by the elongate rail structure.

6. The shoulder rehabilitation and/or exercise device of claim 3, wherein the movable block includes a set of slots, each slot within the set of slots configured for removably receiving a magnet within the first set of magnets.

7. The shoulder rehabilitation and/or exercise device of claim 1, wherein the second set of adjustable magnetically attractive elements comprises:

a magnetic material carried by the base plate;

a first magnet holding structure coupled to the second end of the elongate rail structure and disposed near the pivot element; and

a second set of magnets attachable to and detachable from the first magnet holding structure,

wherein each magnet within the second set of magnets when carried by the first magnet holding structure exerts a magnetic attractive force upon the magnetic material carried by the base plate.

8. The shoulder rehabilitation and/or exercise device of claim 7, wherein the magnetic material carried by the base plate forms the outer surface of the base plate across at least a substantial portion of the planar surface area of the outer surface of the base plate.

9. The shoulder rehabilitation and/or exercise device of claim 7, wherein the second set of magnets includes a plurality of magnets, each magnet within the second set of magnets when held by the magnet holding structure providing a predetermined magnetic attractive force upon the magnetic material carried by the base plate.

10. The shoulder rehabilitation and/or exercise device of claim 7, further comprising:

a second magnet holding structure disposed proximate to the pivot element;

a third set of magnets attachable to and detachable from the second magnet holding structure,

wherein the third set of magnets when held by the second magnet holding structure provides (a) an attractive force with respect to the first set of adjustable magnetically attractive elements in a manner that opposes displacement of the movable block away from a bottom-most position along the guide rail, or (b) a repulsive force with respect to the first set of adjustable magnetically attractive elements in a manner that opposes displacement of the movable block toward the bottom-most position along the guide rail.

11. The shoulder rehabilitation and/or exercise device of claim 1, wherein the base plate further includes a bottom surface disposed beneath the outer surface of the base plate, and wherein the shoulder rehabilitation and/or exercise device further comprises a stand structure including:

a support arm coupled to the under surface of the base plate; and

an elevation bar coupled to the base plate, the elevation bar extending rearward behind the under surface of the base plate, the elevation bar configured for securely receiving the support arm at multiple support arm angles relative to the base plate for adjustable selection of a base plate angle of inclination relative to a planar surface of an object above which the base plate resides.

12. The shoulder rehabilitation and/or exercise device of claim 11, wherein the stand structure further includes at least one clamp coupled to the elevation bar and the base plate.

13. The shoulder rehabilitation and/or exercise device of claim 11, wherein the stand structure further includes a set of hinges by which the base plate and the elevation bar can be pivotally folded or opened relative to each other.

14. The shoulder rehabilitation and/or exercise device of claim 1, wherein the shoulder rehabilitation and/or exercise device is configured to facilitate multiple categorical types of shoulder rehabilitation exercises or movements including each of shoulder flexion / extension, shoulder adduction / abduction, and shoulder internal / external rotation.

15. A method for performing shoulder rehabilitation exercises or movements, comprising:

providing a shoulder rehabilitation / exercise device comprising:

a base plate having an inner border and an outer border, the base providing an outer surface having a planar surface area between the inner border and the outer border;

a pivot element coupled to the base plate, the pivot element defining a pivot axis perpendicular to the outer surface of the base plate;

an elongate rail structure disposed adjacent to the base plate and coupled to the pivot element in a manner that enables clockwise and counterclockwise rotation of the elongate rail structure relative to the pivot axis, the elongate rail structure having a first end proximate to the pivot element, a second end that

resides beyond the outer surface of the base plate, a length that extends along a rail axis between the first end and the second end of the elongate rail structure, and an outer surface along its length, the outer surface of the elongate rail structure at least generally parallel to the outer surface of the base plate;

a guide bar supported supported above and extending parallel to the elongate rail structure, the guide bar having a predetermined length;

a movable block slidably displaceable along a substantial portion of the length of the guide bar;

a first set of adjustable magnetically attractive elements for selectively providing a first set of counter forces that oppose or act against linear displacement of the movable block parallel to the rail axis *r*;

a second set of adjustable magnetically attractive elements for selectively providing a second set of counter forces that oppose or act against rotational displacement of the movable block relative to the pivot axis *p*; and

a handle coupled to the movable block, the handle configured for communicating user forces to the movable block to selectively (a) displace the movable block parallel to the rail axis *r* and/or (b) rotate the movable block relative to the pivot axis *p*;

establishing a level of the first set of counter force for opposing linear displacement of the movable block parallel to the rail axis *r* by way of adjustment of the first set of adjustable magnetically attractive elements; and

establishing a level of the second set of counter forces for opposing rotational displacement of the movable block relative to the pivot axis *p* by way of adjustment of the second set of adjustable magnetically attractive elements.

16. The method of claim 15, further comprising establishing an angle of inclination of the base plate relative to a planar surface of an object above which the base plate resides.

17. The method of claim 16 or 17, further comprising delivering user forces to the movable block by way of the handle to thereby (a) displace the movable block parallel to the rail axis *r*, and/or (b) rotate the movable block relative to the pivot axis *p*.