SUMMARY

[0010] An aspect of the present disclosure provides a shoulder rehabilitation device comprising an elongated structure configured to support an arm of a patient, the patient being in a lying position, and a force generator mounted to the elongated structure and configured to apply a traction force on the arm in a distal direction relative to the arm. The elongated structure is rotatable about a pivot adjacent a shoulder joint of said arm. The force generator is further configured to control the traction force to be within a predetermined range. The elongated structure comprises a proximal end and a distal end opposite the proximal end, and wherein the force generator is mounted at the distal end of the elongated structure. The force generator comprises a wrist cuff configured to securely wrap around a wrist of said arm; at least one strap extending distally from the wrist cuff; an elastic member connected to the at least one strap and extending toward the distal end of the elongated structure; and a motor configured to pull a distal end of the at least one elastic member for generating the traction force. A torque and a speed of the motor are configured based on an attribute of the patient.

[0011] The elongated structure may be supported by a stand, and a height of the stand is adjustable. The elongated structure may be pivotable relative to the stand between an extended first position in which the elongated structure is substantially perpendicular to the stand and a folded second position in which the elongated structure is substantially parallel to the stand.

[0012] The stand may be removably mounted on a base, and the base may comprise a plurality of wheels. At least one of the wheels may be configured to be driven by a motor.

[0013]

[0014]

[0015] The device may further comprise a force sensor configured to measure the traction force. The device may also comprise a controller coupled to the at least one motor and configured to control the motor. The device may further comprise a display configured to display the traction force.

[0016] The device may further comprise at least one visual indicator configured to generate a visual notification if the traction force is outside the predetermined range. Alternatively or in addition, the device may further comprise at least one audio indicator configured to generate an audio notification if the traction force is outside the predetermined range.

[0017] The force generator may further comprise an upper arm cuff configured to securely wrap around an upper arm region, the upper arm cuff being connected to the wrist cuff.

[0018] There is also disclosed shoulder rehabilitation method comprising supporting an arm of a patient on an elongated structure while the patient is in a lying position; applying a traction force on the arm in a distal direction relative to the arm, using a force generator mounted to the elongated structure, such that the traction force is within a predetermined range; and rotating the elongated structure about a pivot adjacent a shoulder joint of said arm to abduct said arm.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] Embodiments of the disclosure will be better understood and readily apparent to one of ordinary skill in the art from the following written description, by way of example only, and in conjunction with the drawings, in which:

[0020] Figure 1(a) shows a shoulder rehabilitation device in an extended position according to an example embodiment.

[0021] Figure 1(b) shows positioning of a patient relative to the shoulder rehabilitation device of Figure 1(a).

[0022] Figure 1(c) shows the shoulder rehabilitation device of Figure 1(a) in a folded position.

[0023] Figure 2(a) shows a first perspective view of a shoulder rehabilitation device according to an alternate embodiment.

[0024] Figure 2(b) shows a second perspective view of the shoulder rehabilitation device of Figure 2(a).

[0025] Figure 2(c) shows a top view of the shoulder rehabilitation device of Figure 2(a).

[0026] Figure 3 shows a plot of traction force against abduction angle according to an example embodiment.

[0027] Figure 4 shows a force sensing system according to an example embodiment.

[0028] Figure 5 shows a simplified block diagram of a circuit implementing the force sensing system of Figure 4 according to an example embodiment.

[0029] Figure 6 shows a flow chart illustrating a shoulder rehabilitation method according to an example embodiment.

[0030] Skilled artisans will appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been depicted to scale. For example, the dimensions of some of the elements in the illustrations, block diagrams or flowcharts may be exaggerated in respect to other elements to help to improve understanding of the present embodiments.

DETAILED DESCRIPTION

[0031] The present disclosure provides an assistive mechanical device that performs abduction and traction for shoulder rehabilitation, for example, to reduce an anteriorly dislocated shoulder. Functionally, the device includes three modules: an abduction system, a traction system and a force sensing system. The abduction system includes a standing structure with wheels supporting the full length of a patient's arm at a lying down position. The standing structure has a vertical height that is adjustable to ensure alignment with the patient's body, and is able to abduct the hand a full 180-degree motion about the humerus using wheels. In some embodiments, the abduction system is attached to a back plate that allows a patient to lie on to anchor the movement of the device, and straps that are designed ambidextrously are used to minimise movement of the patient during reduction. In some embodiments, the traction system uses adjustable straps to allow clinicians to apply a certain traction force by tightening the straps, wrist guards to prevent injury of the wrist on the patient and ensure minimal movement, and springs to

parallel to the stand 108 (as shown in Figure 1(c)). For example, a locking mechanism can be used to hold the elongated structure 102 in the extended first position. In the folded position, the elongated structure 102 and the stand 108 can be removed from the base 110 for easy stowage.

[0036] The shoulder rehabilitation device 100 also includes a force generator 118 mounted to the elongated structure 102. For example, the elongated structure 102 has a proximal end (near to the pivot for rotation) and a distal end opposite the proximal end, and the force generator 118 is mounted at the distal end. The force generator 118 can apply a traction force on the arm 104 in a distal direction relative to the arm 104 and control the traction force to be within a predetermined range, e.g. between 5 and 18 kgf as described in further details below.

[0037] As shown in Figures 1(a) and 1(c), the force generator 118 includes a wrist cuff 120 that can securely wrap around a wrist the arm 104, at least one strap 122 extending distally from the wrist cuff 120, and an elastic member 124 connected to the at least one strap 122 and extending toward the distal end of the elongated structure 102. The length of the at least one strap 122 can be manually adjustable for generating the traction force. For example, the at least one strap 122 can be shortened to increase the traction force, or lengthened to decrease the traction force. The elastic member 124 can help to dampen the change in the traction force such that any change is not sudden, thereby reducing discomfort to the patient 106.

[0038] In some embodiments, the force generator 118 also includes a force sensor to measure the traction force and a display to display the measured traction force. Further, visual and/or audio feedback devices in the form of indicator lights, buzzer, etc. can be incorporated to inform the clinician that the traction force is too low (i.e. not sufficient) or too high (i.e. not safe or comfortable). For example, if a clinically acceptable range of the traction force is 5 to 18 kgf, the feedback devices can be programmed to be triggered if the measured traction force is outside this range.

[0039] In an example deployment of the shoulder rehabilitation device 100, the back support 114 is first placed on the bed 116. The elongated structure 102 and stand 108 are mounted on the base 110 and the height of the stand 108 is adjusted such that the elongated structure 102 is aligned with the level of the back support 114. The back support is then connected to the elongated structure 102 at the pivot hinge and its lateral position on the bed 116 is adjusted based on the patient’s height. The patient 106 can then lie on the back support 114

[0043] In use, the patient may be requested to lie on a back support 214 in a supine position and a strap 228 may be used to secure the patient's body from lateral movement. The back support 214 may be placed on a bed or a bench. The patient's arm with the dislocated shoulder is placed on the elongated structure 202 at a height level with the patient's body. Two rods 230, which may be located at a side of the back support 214, may be used as fixation device to prevent the shoulder joint of the patient from displacing. The wrist cuff 220 is strapped around the wrist. In addition, an upper arm cuff 232, which is connected to the wrist cuff 220, is used to securely wrap around the upper arm area to provide distributed force during the rotation of the elongated structure 202. This can help to avoid issues like arm fracture if the force is concentrated at the wrist region. The motor 226 pulling the elastic member 224 is activated to provide the necessary traction force, and the motor driving at least one of the wheels 212 is activated provide needed rotation of the shoulder while maintaining the distal force. In some embodiments, an encoder is disposed at pivot 216 to monitor the rotation.

[0044] By making use of motorized components, the shoulder rehabilitation device 200 can reduce the physical exertion of the clinician while providing relaxation of the shoulder muscles throughout the abduction to enable the humeral head to enter the glenoid cavity smoothly. The required manpower, as well as supervision, can be reduced such that one-person operation is possible, and standardisation of reduction and rehabilitation procedures can be achieved. The shoulder rehabilitation device 200 is also safe and gentle with minimal monitoring, and does not require the use of anesthesia. An over-ride/abort safety feature may be incorporated to allow the clinician to intervene if necessary.

[0045] The shoulder rehabilitation device as described with reference to Figures 1(a)-1(c) and Figures 2(a)-2(b) can also be considered as having three separate sub-systems each with its own functions, namely, the abduction system, the traction system, and the force sensing system.

[0046] The abduction system (comprising the elongated structure, stand and base) guides the arm in the desired motion which is abduction in the coronal plane from the caudal direction to the cranial direction. The traction system (part of the force generator) provides the traction force required to relax the shoulder muscles to allow the humeral head to be moved back into the glenoid cavity of the shoulder blade. The force sensing system (part of the force generator) is used to indicate to the clinician the exact force that is applied on the patient while ensuring that the

CLAIMS

1. A shoulder rehabilitation device comprising:

an elongated structure configured to support an arm of a patient, the patient being in a lying position; and

a force generator mounted to the elongated structure and configured to apply a traction force on the arm in a distal direction relative to the arm,

wherein the elongated structure is rotatable about a pivot adjacent a shoulder joint of said arm;

wherein the force generator is further configured to control the traction force to be within a predetermined range;

wherein the elongated structure comprises a proximal end and a distal end opposite the proximal end, and wherein the force generator is mounted at the distal end of the elongated structure; and

wherein the force generator comprises:

a wrist cuff configured to securely wrap around a wrist of said arm;

at least one strap extending distally from the wrist cuff;

an elastic member connected to the at least one strap and extending toward the distal end of the elongated structure; and

a motor configured to pull a distal end of the at least one elastic member for generating the traction force,

wherein a torque and a speed of the motor are configured based on an attribute of the patient.

2. The device as claimed in claim 1, wherein the elongated structure is supported by a stand, and wherein a height of the stand is adjustable.

3. The device as claimed in claim 2, wherein the elongated structure is pivotable relative to the stand between an extended first position in which the elongated structure is substantially perpendicular to the stand and a folded second position in which the elongated structure is substantially parallel to the stand.

4. The device as claimed in claim 2 or 3, wherein the stand is removably mounted on a base, and wherein the base comprises a plurality of wheels.

5. The device as claimed in claim 4, wherein at least one of the wheels is configured to be driven by a motor.

6. The device as claimed in any one of the preceding claims, further comprising a force sensor configured to measure the traction force.

7. The device as claimed in any one of the preceding claims, further comprising a controller coupled to the at least one motor and configured to control the motor.

8. The device as claimed in claim 6, further comprising a display configured to display the traction force.

9. The device as claimed in claim 6, further comprising at least one visual indicator configured to generate a visual notification if the traction force is outside the predetermined range.

10. The device as claimed in claim 6, further comprising at least one audio indicator configured to generate an audio notification if the traction force is outside the predetermined range.

11. The device as claimed in any one of the preceding claims, wherein the force generator further comprises an upper arm cuff configured to securely wrap around an upper arm region, the upper arm cuff being connected to the wrist cuff.