IeCAT 2020
The 1st International Electronic Conference on Actuator Technology
Materials, Devices and Applications
23–27 NOVEMBER 2020 | ONLINE
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Robotic Orthosis for Upper Limb Rehabilitation

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Summary

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Introduction

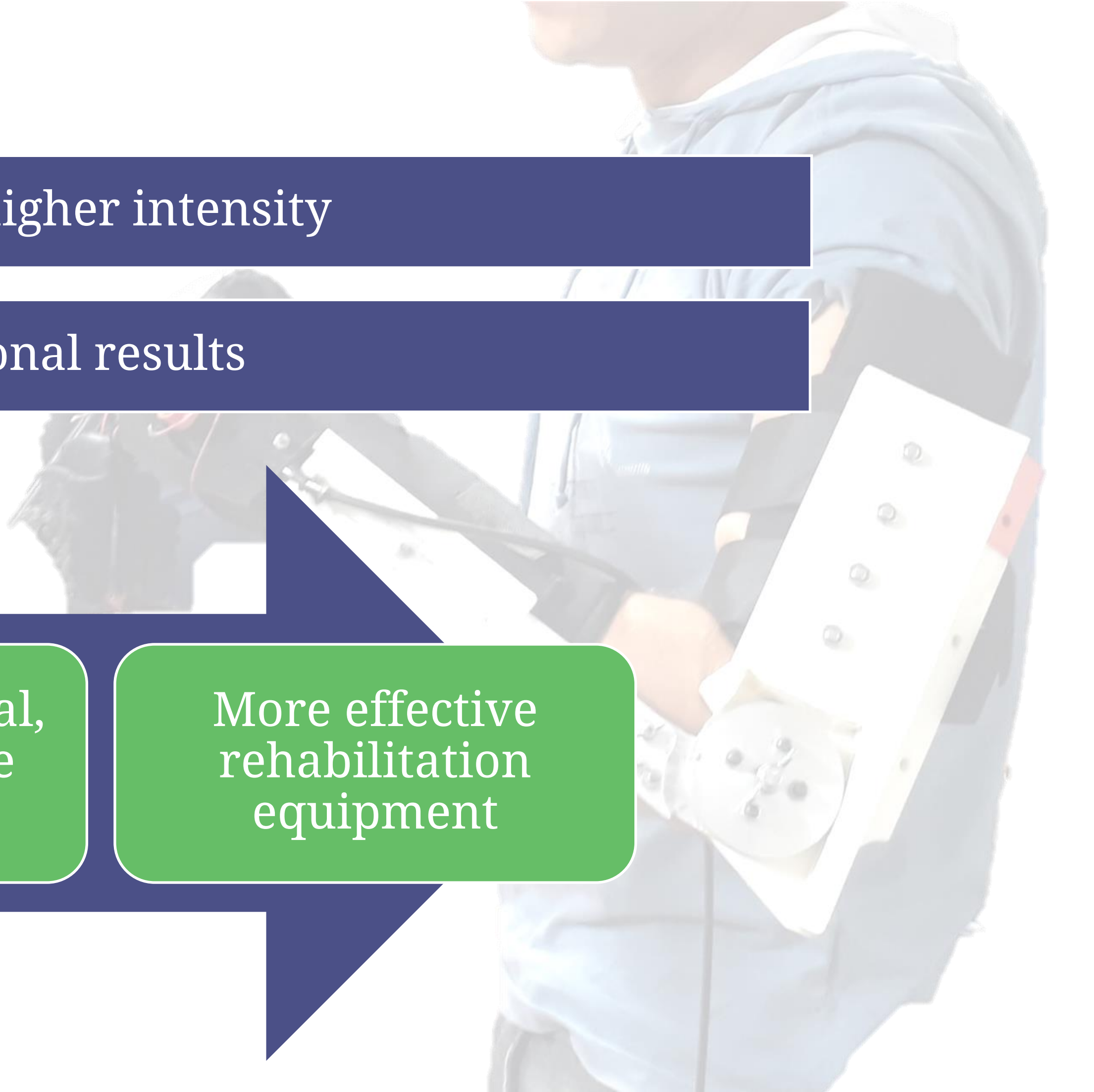
- Stroke - clinical syndrome
- One of the main causes of death and disability

Upper extremity - 70% of individuals → 30 to 66% of patients do not have upper limb function on the affected side → 5% to 20% demonstrate complete functional recovery

Introduction

- Robot-assisted therapy: training in dosage and much higher intensity
- Improve the strategies of relearning motor and functional results

Disadvantages of robotic orthoses for upper limb rehabilitation → High cost, material, and unfavorable aesthetics → More effective rehabilitation equipment



Introduction

WHAT IS THE AIM OF THIS STUDY?

- Develop a robotic orthosis
- Individuals with motor impairment of the upper limb resulting from a stroke
- Help flexion and extension movements of the elbow and fingers
- Validate the device in volunteers

Experiments

DEVICE

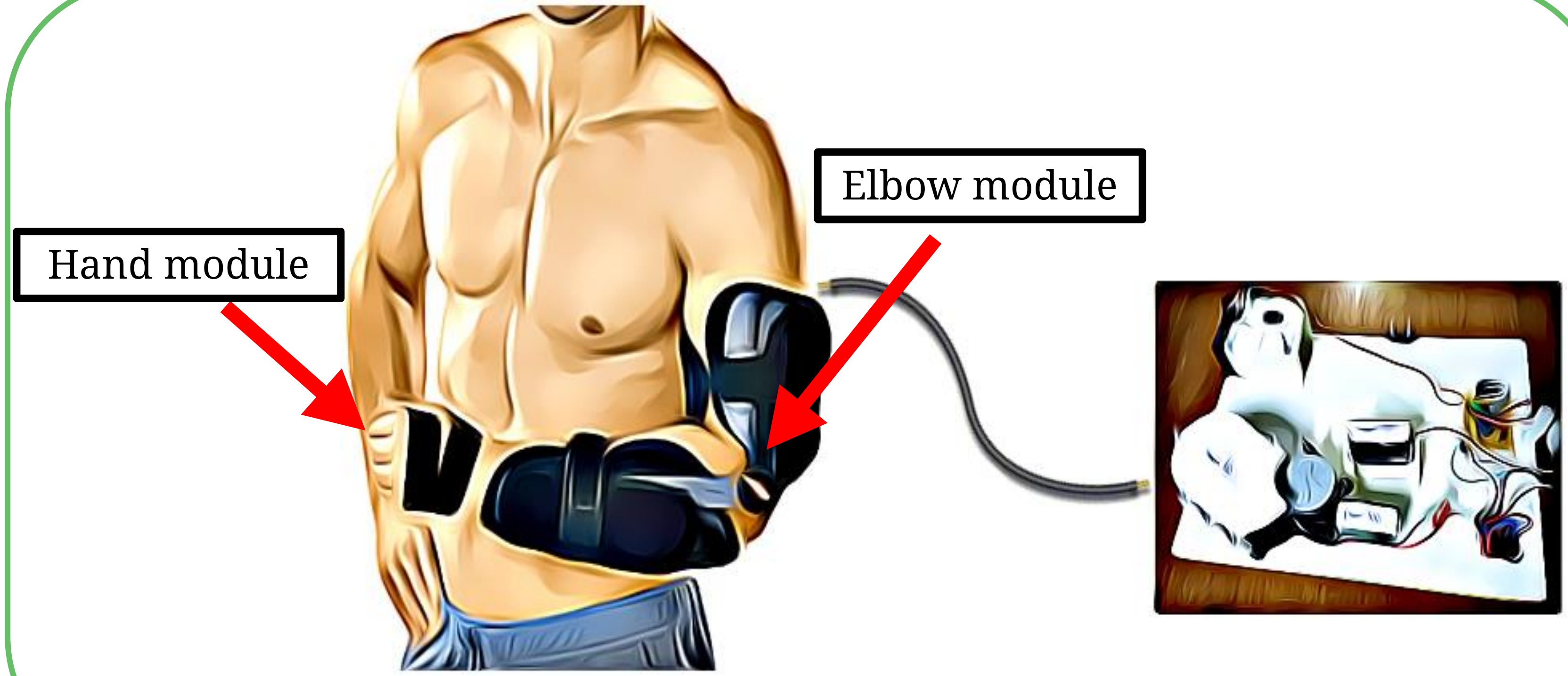


Figure 1. Schematic representation of the device developed [1].

- Hand module
  - Static orthosis
  - Mechanical structure
- Elbow module
  - Static orthosis
  - Mechanical structure
- Control
- Clinical test

Experiments

HAND MODULE-MECHANICAL DESIGN

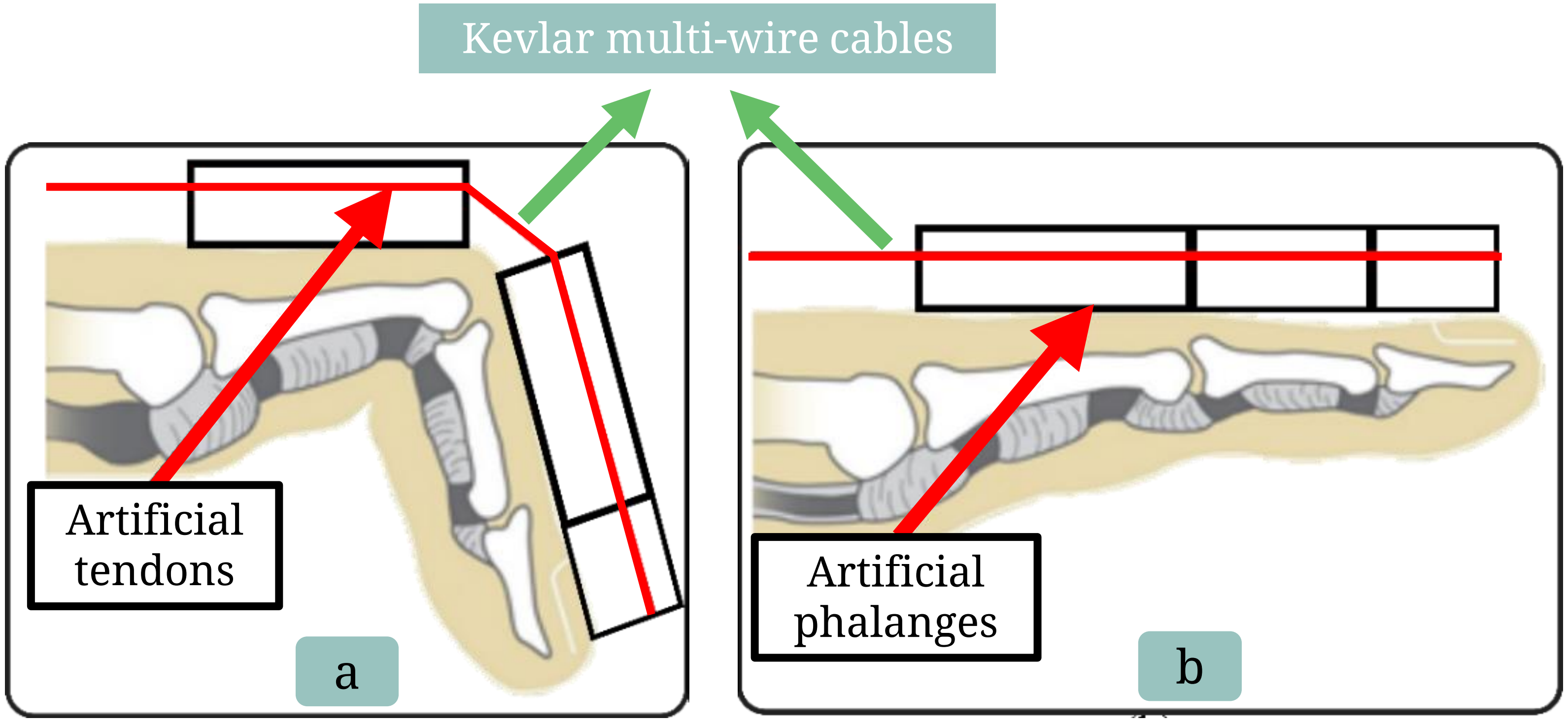
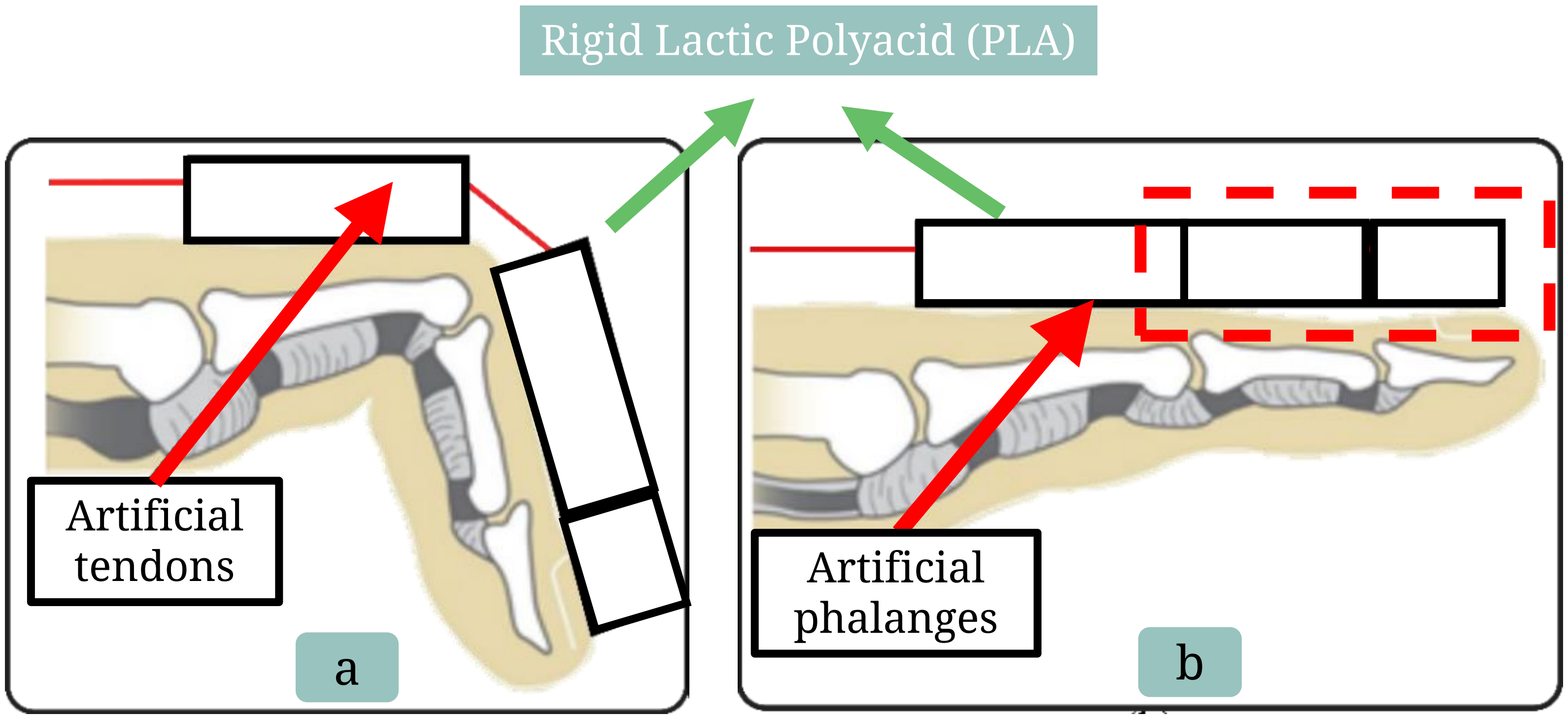


Figure 2. Schematic mechanism representation of (a) closing and (b) opening fingers with artificial phalanx and tendons. Adapted from Rúbio et al. [2].

- Artificial tendons
- Artificial phalanges
- Artificial metacarpal
- Fingerstall

Experiments

HAND MODULE-MECHANICAL DESIGN



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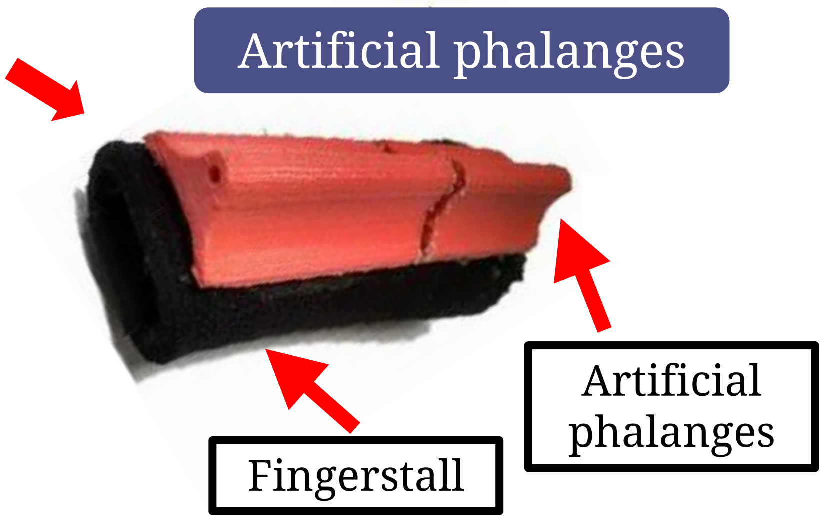


Figure 3. Artificial phalanx attached to the fingerstall [1].

Experiments

HAND MODULE-MECHANICAL DESIGN

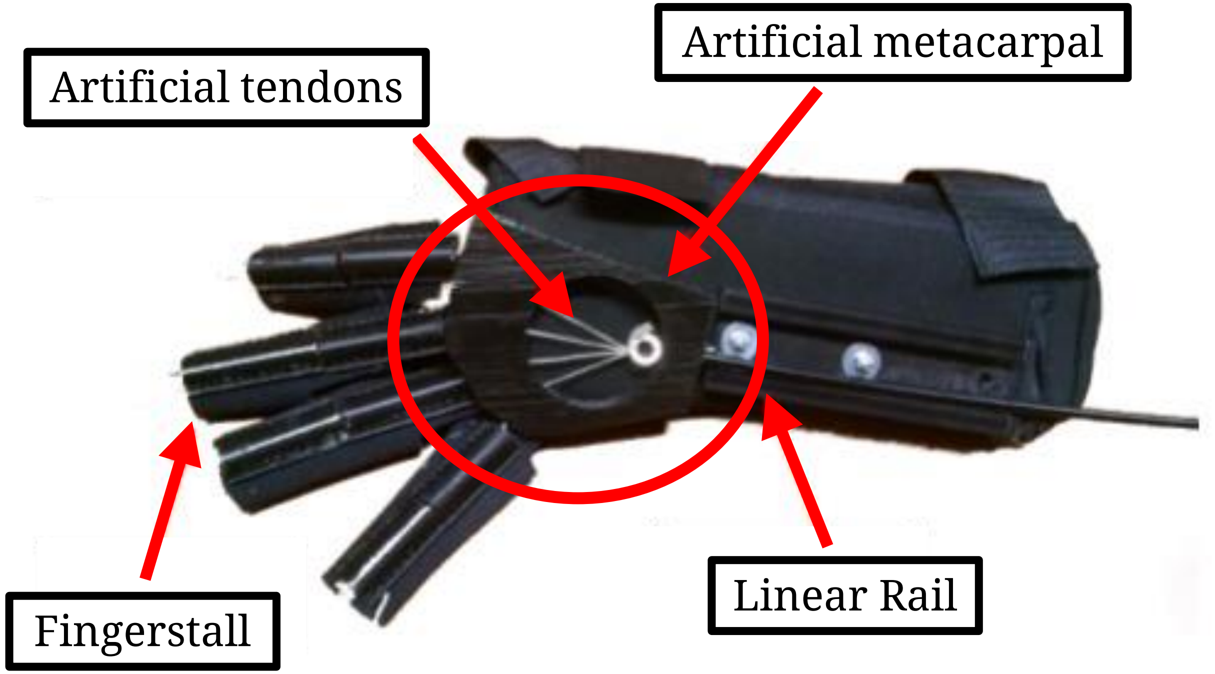


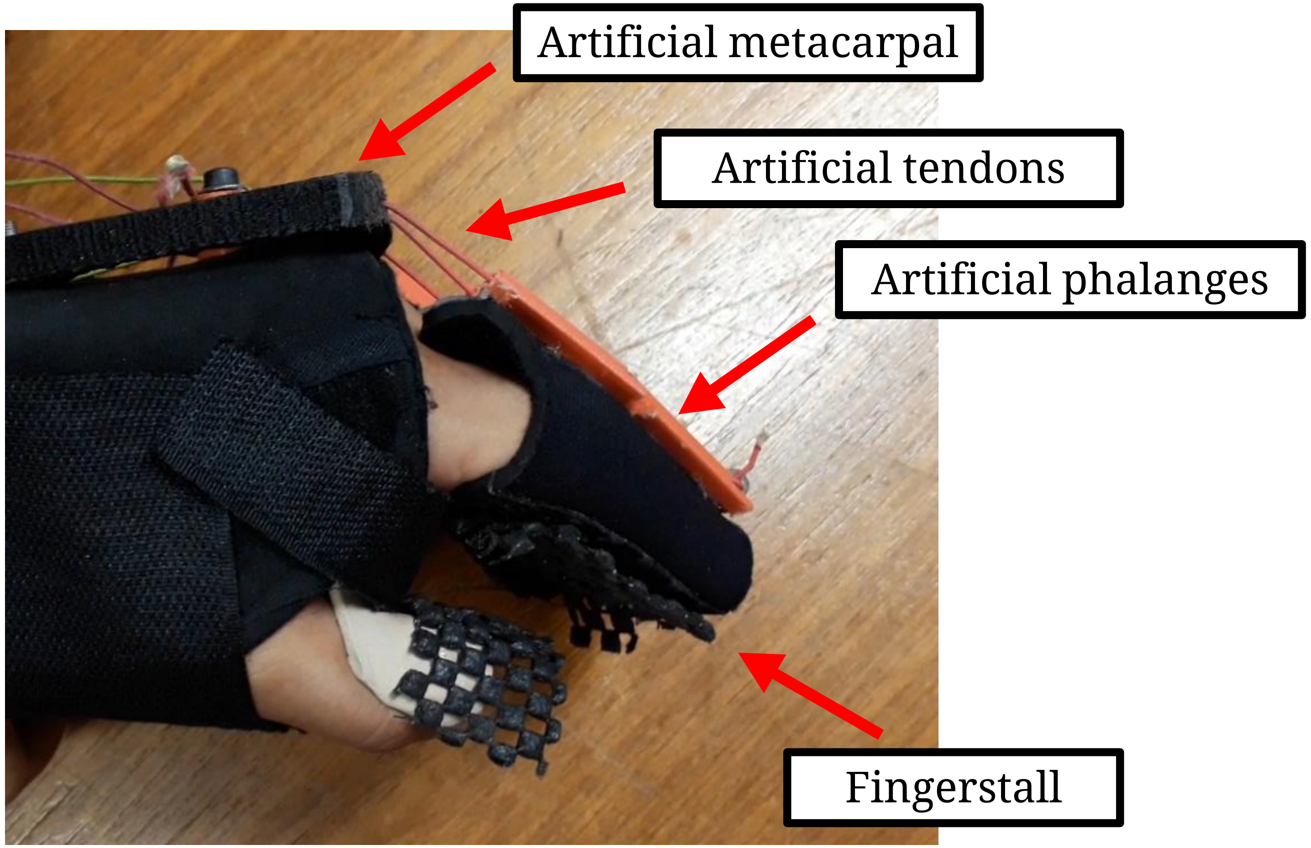
Figure 4. Hand module [1].

Support and connection

Artificial metacarpal

Experiments

HAND MODULE-MECHANICAL DESIGN



Fingerstall

Experiments

HAND MODULE-MECHANICAL DESIGN

Extension and flexion movement

Fingerstall

Experiments

HAND MODULE-STATIC STRUCTURE

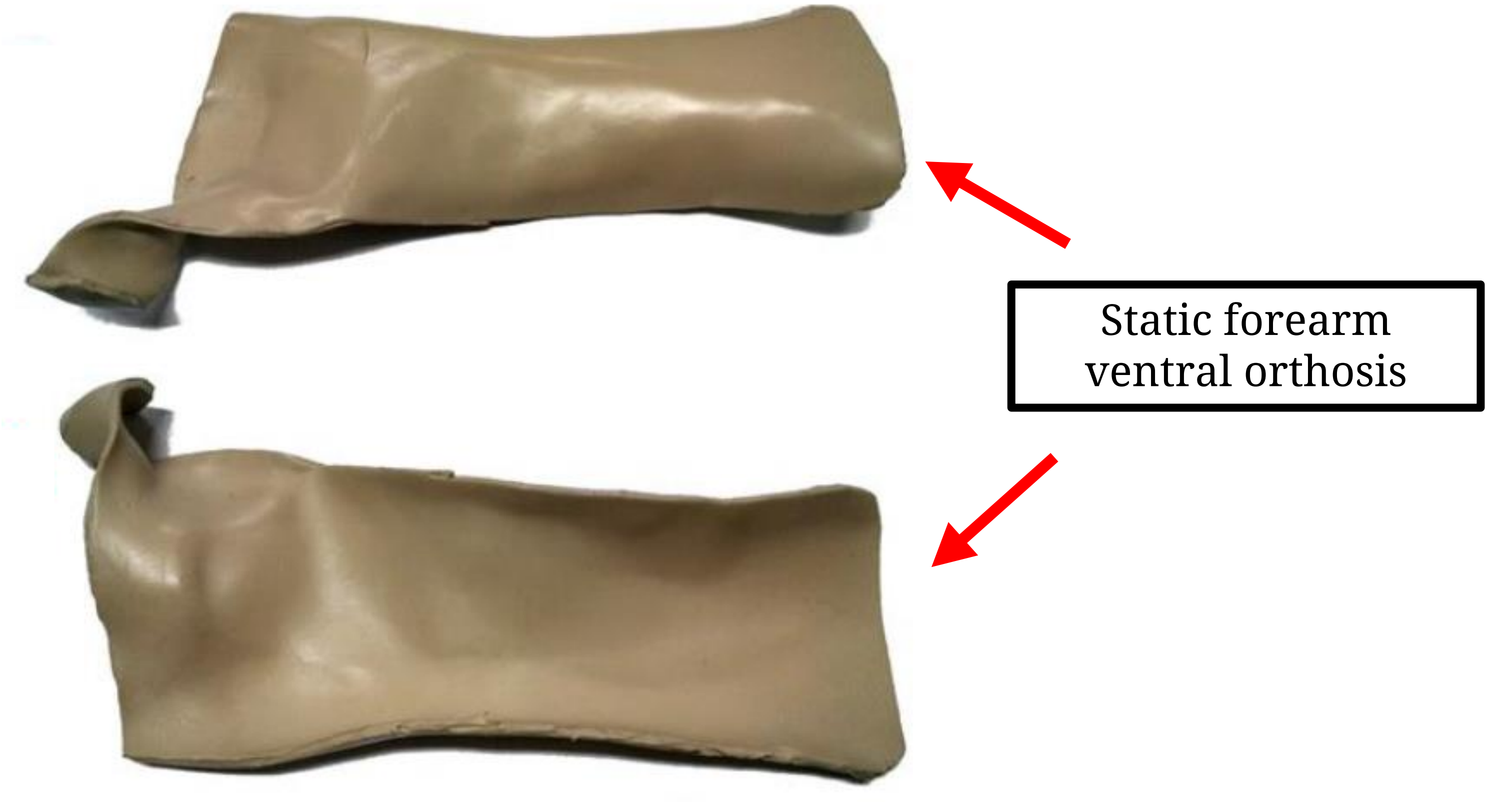


Figure 5. Static forearm ventral orthosis [1].

Experiments

HAND MODULE-STATIC STRUCTURE

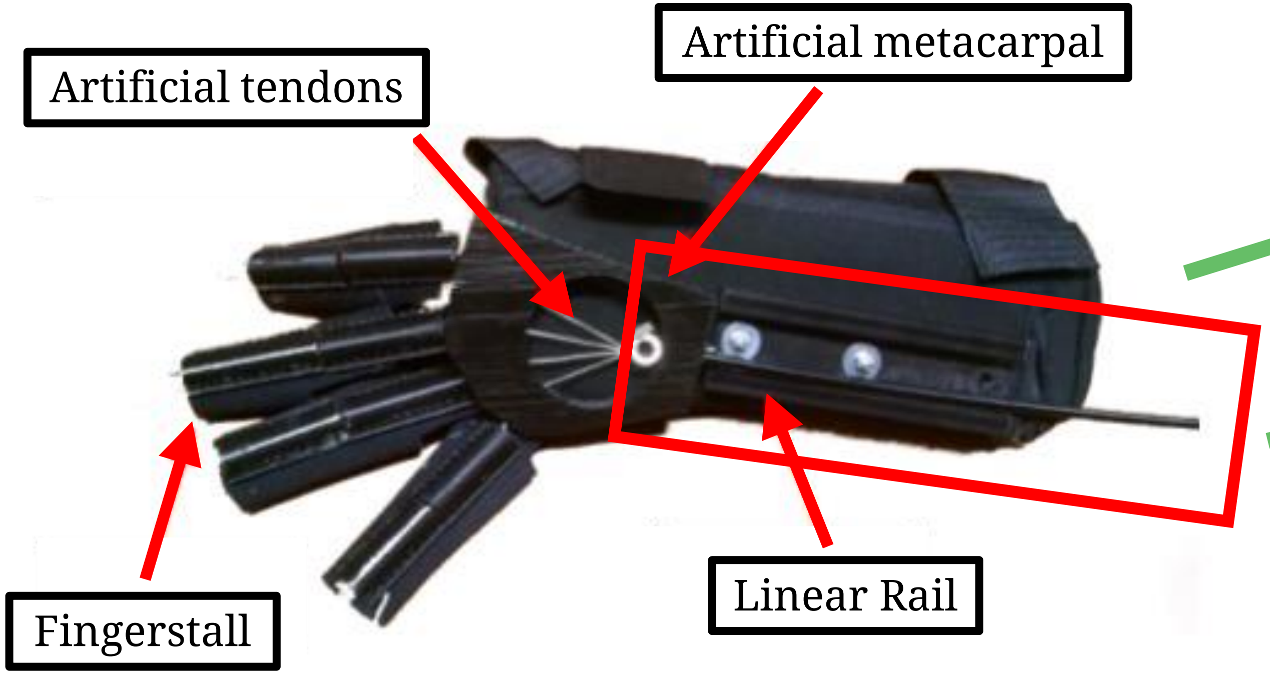


Figure 4. Hand module [1].

Connect the hand module to the elbow module

Second degree of freedom

Experiments

ELBOW MODULE-MECHANICAL DESIGN

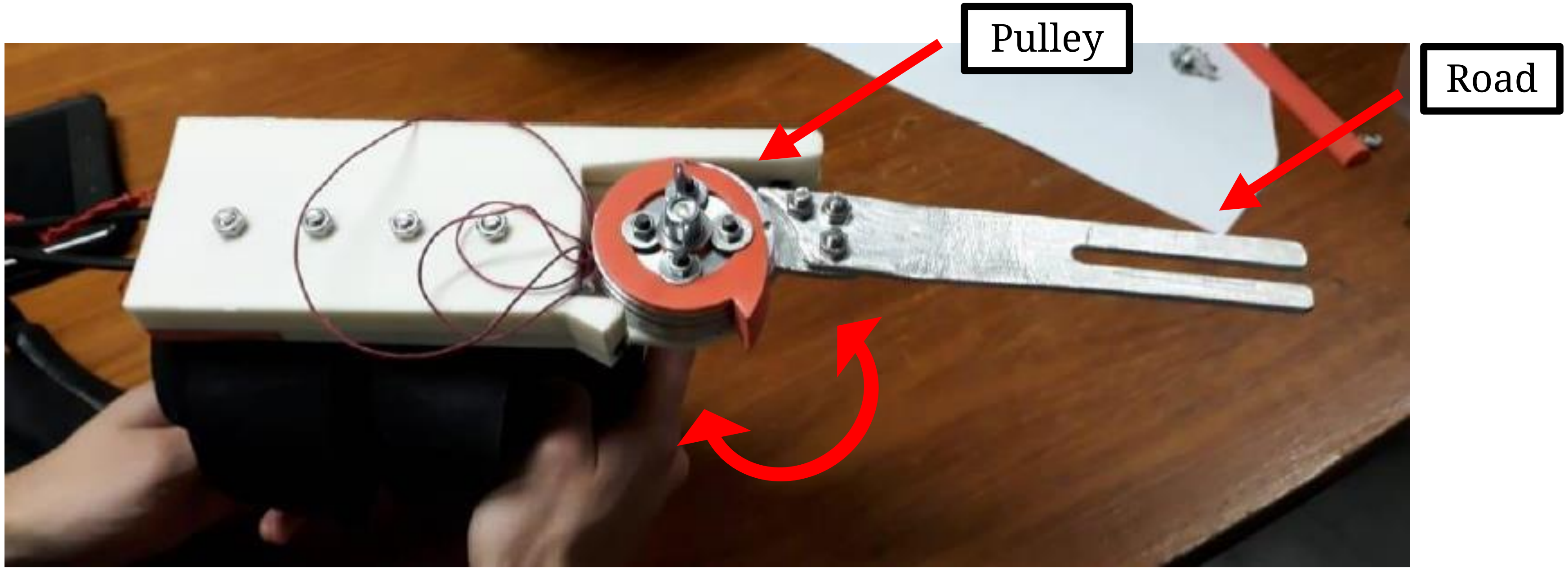


Figure 6. The elbow module [1].

Experiments

ELBOW MODULE-MECHANICAL DESIGN

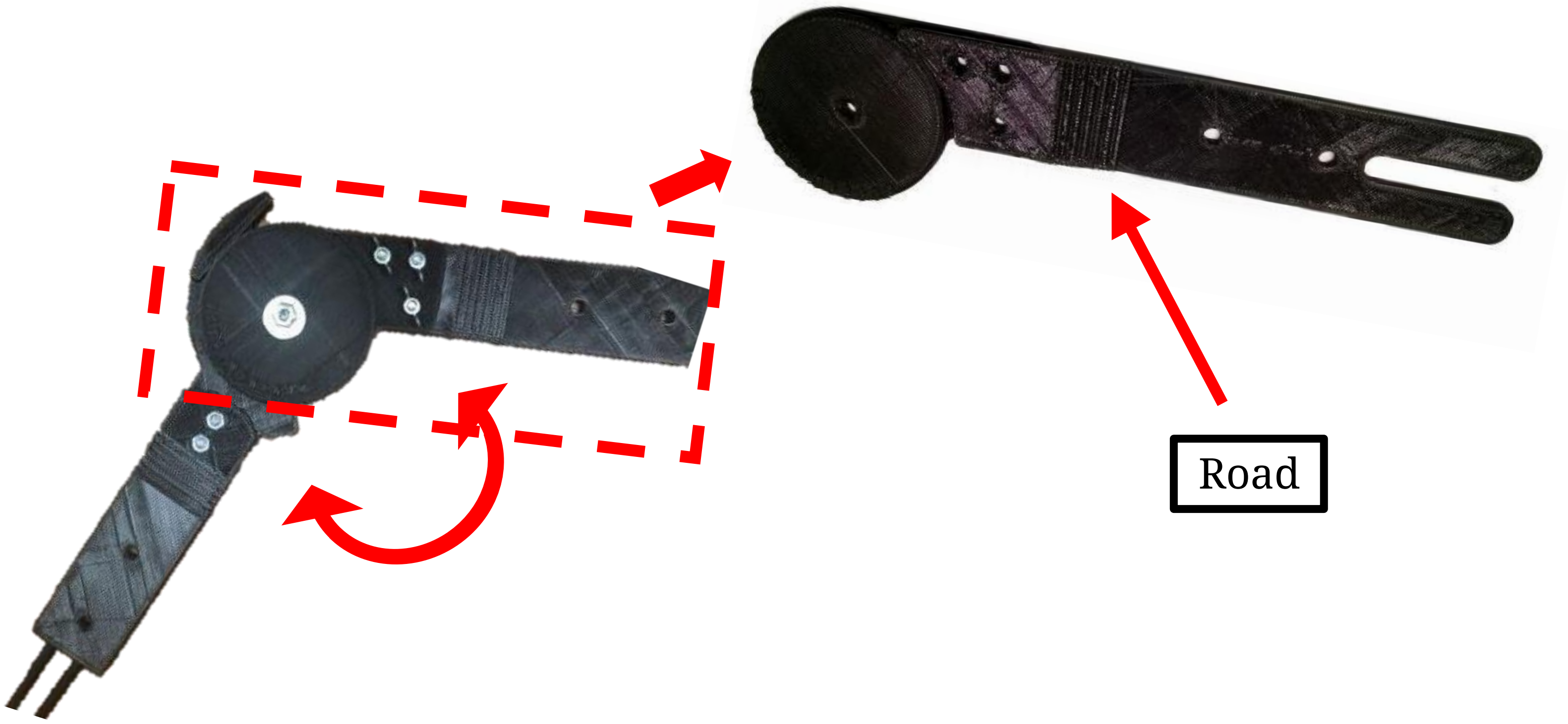


Figure 7. The elbow joint [1].

Experiments

ELBOW MODULE-MECHANICAL DESIGN

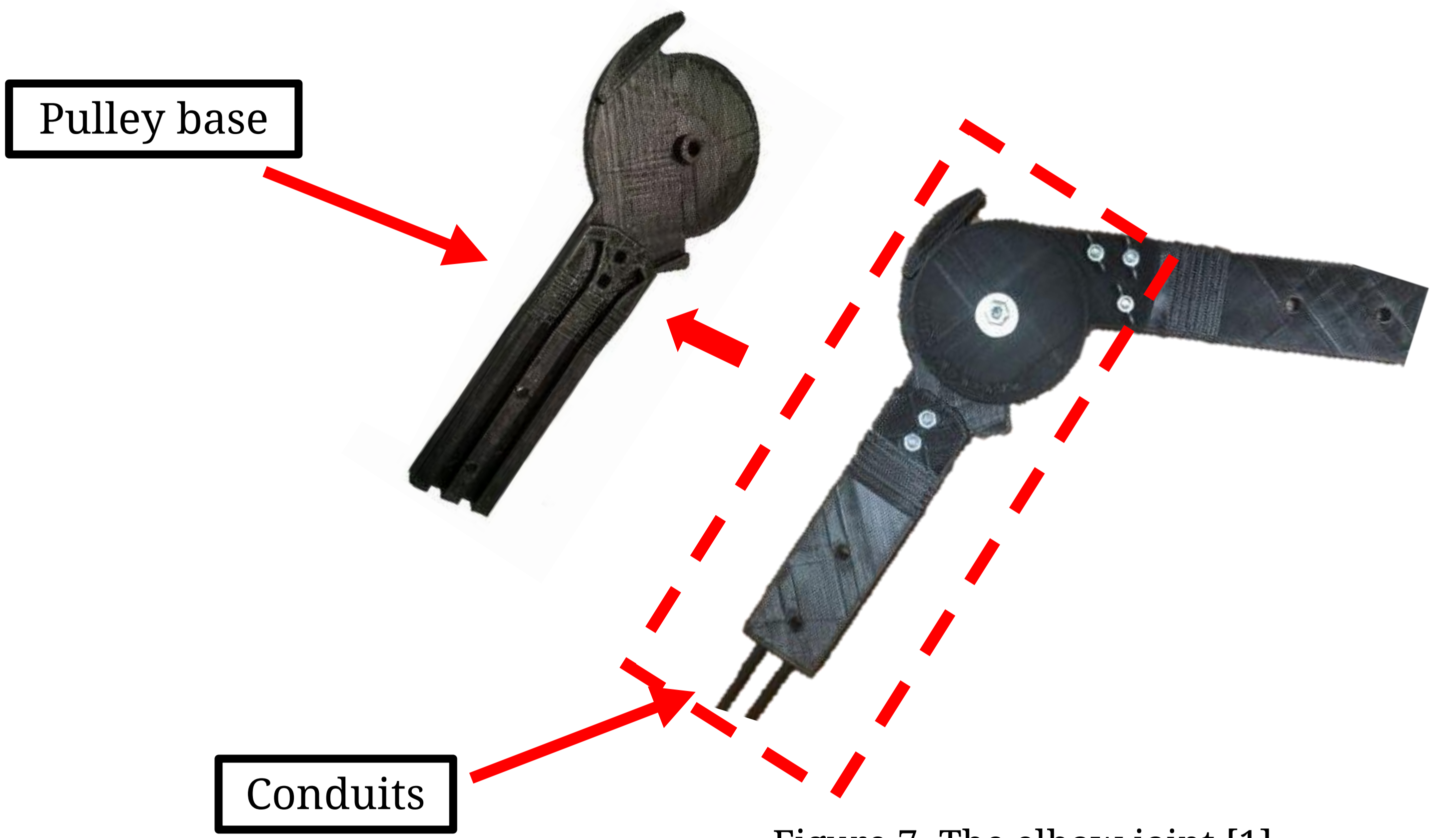


Figure 7. The elbow joint [1].

Experiments

ELBOW MODULE-MECHANICAL DESIGN

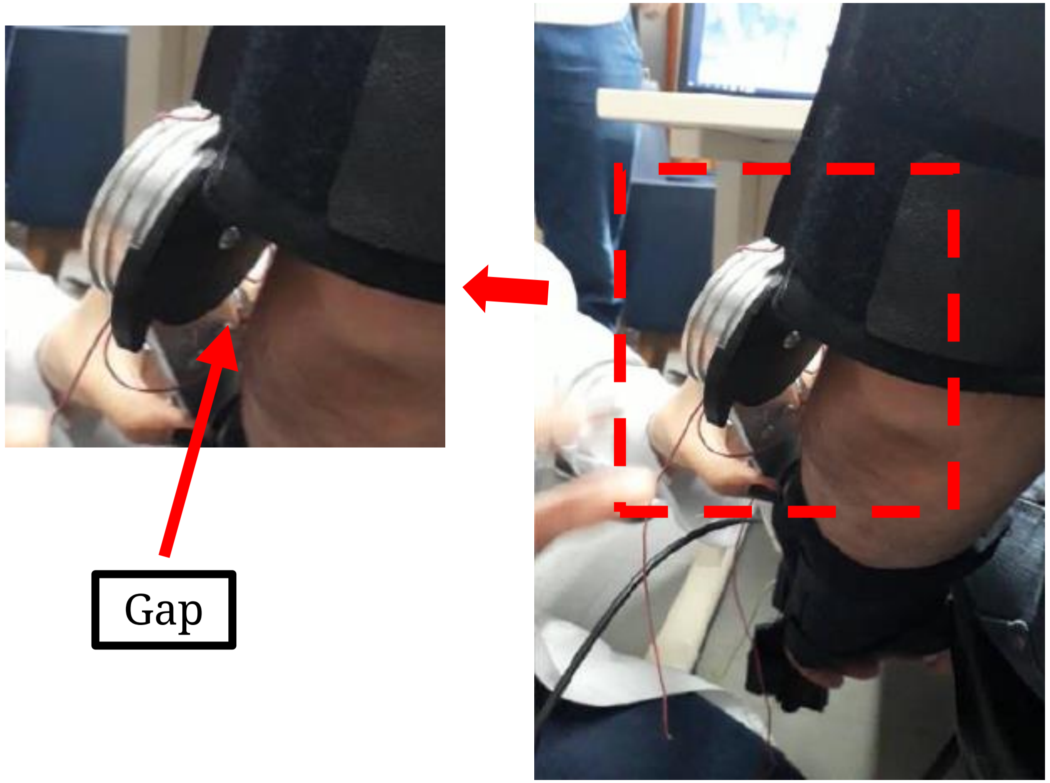


Figure 8. The pulley base twisting [1].

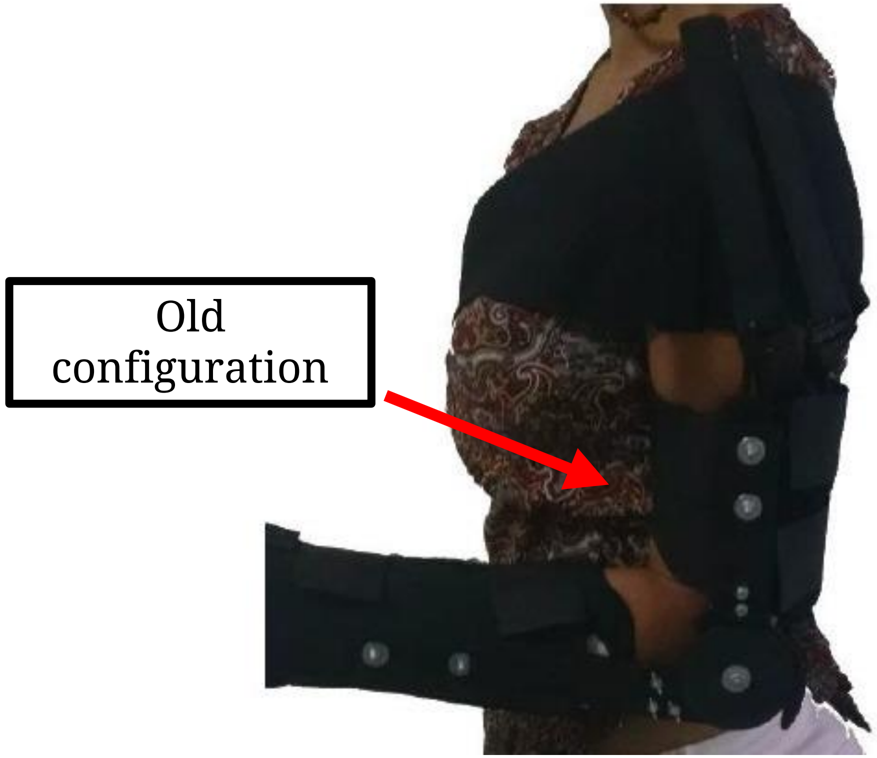
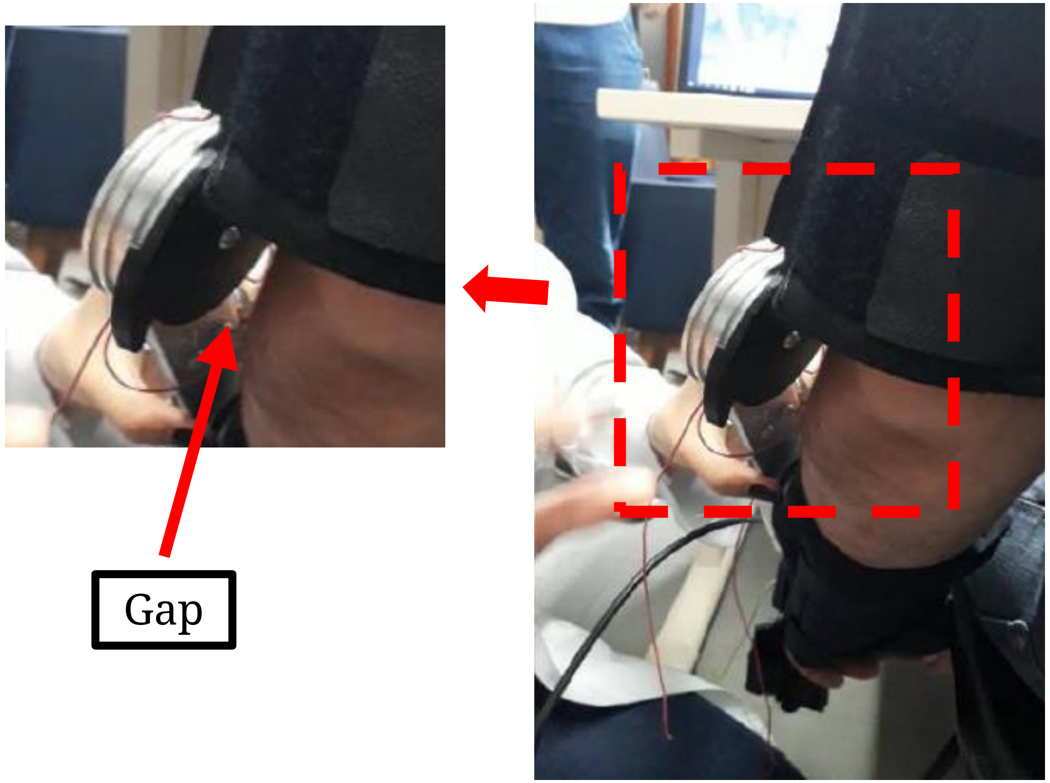


Figure 9. Orthosis: old configuration [1].

Experiments

ELBOW MODULE-MECHANICAL DESIGN



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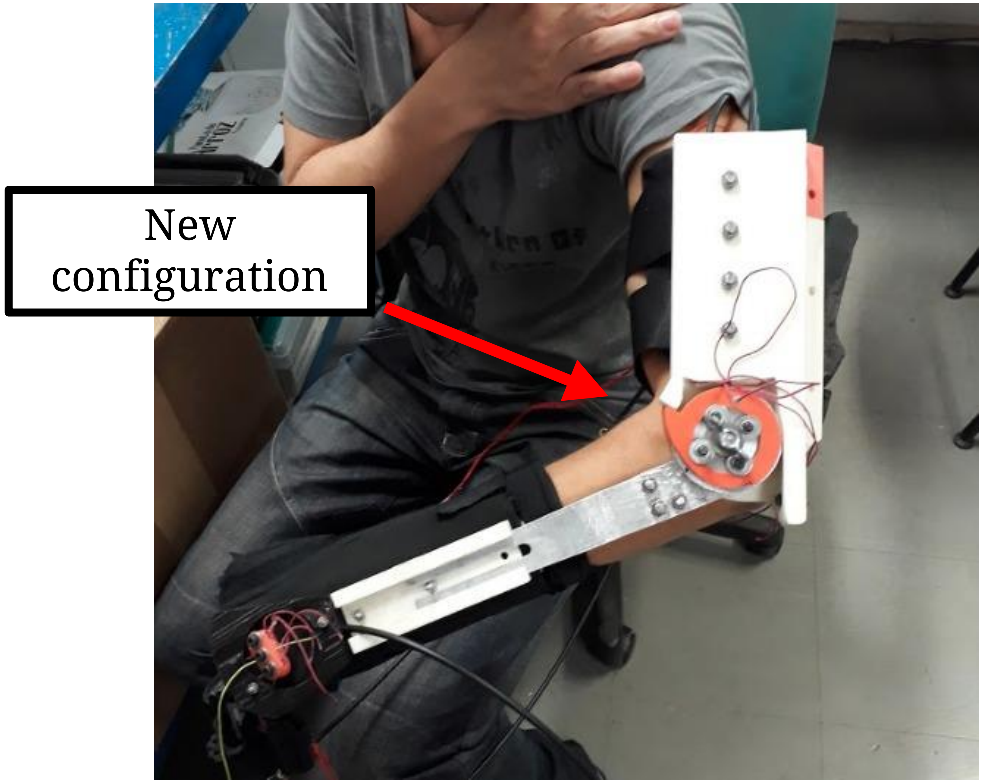


Figure 10. Orthosis: new configuration [1].

Experiments

ELBOW MODULE-STATIC STRUCTURE

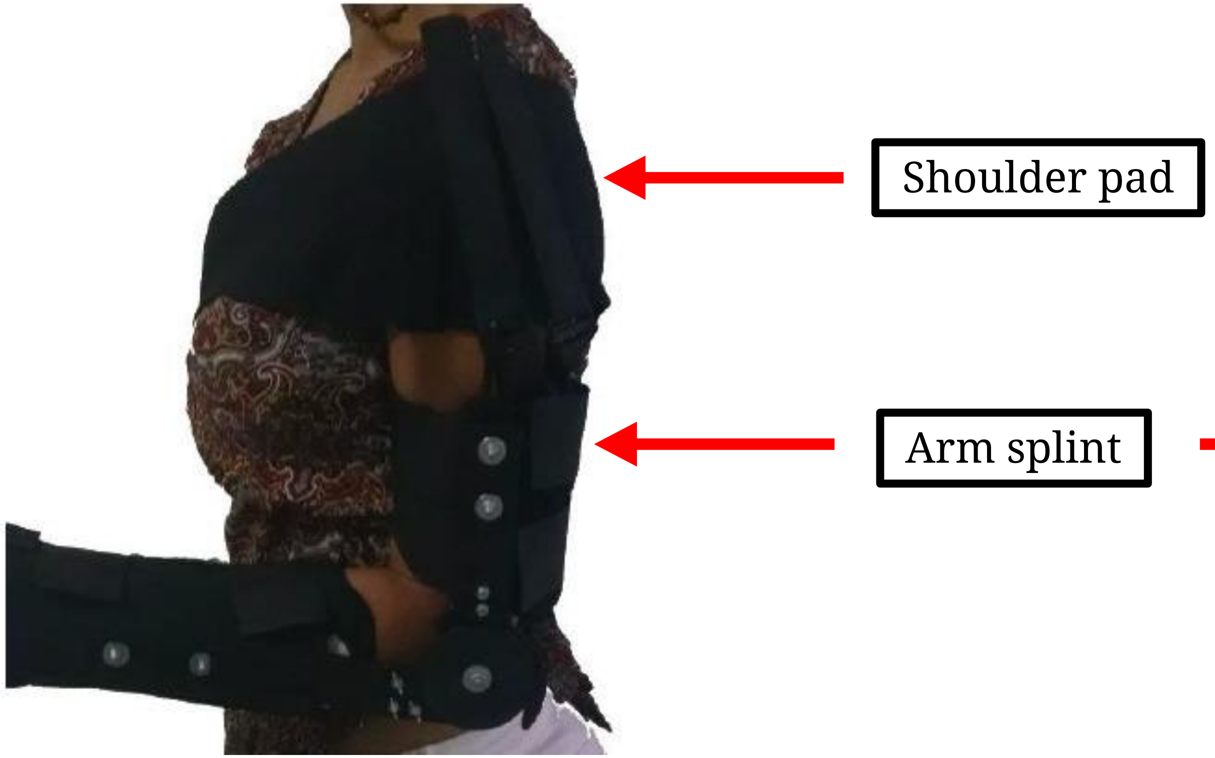


Figure 9. Orthosis: old configuration [1].

Figure 11. Thermoplastic arm splint [1].

Experiments

ELBOW MODULE-STATIC STRUCTURE

Figure 9. Orthosis: old configuration [1].

Figure 12. Shoulder pad [1].

Experiments

MOTORS AND CONTROL

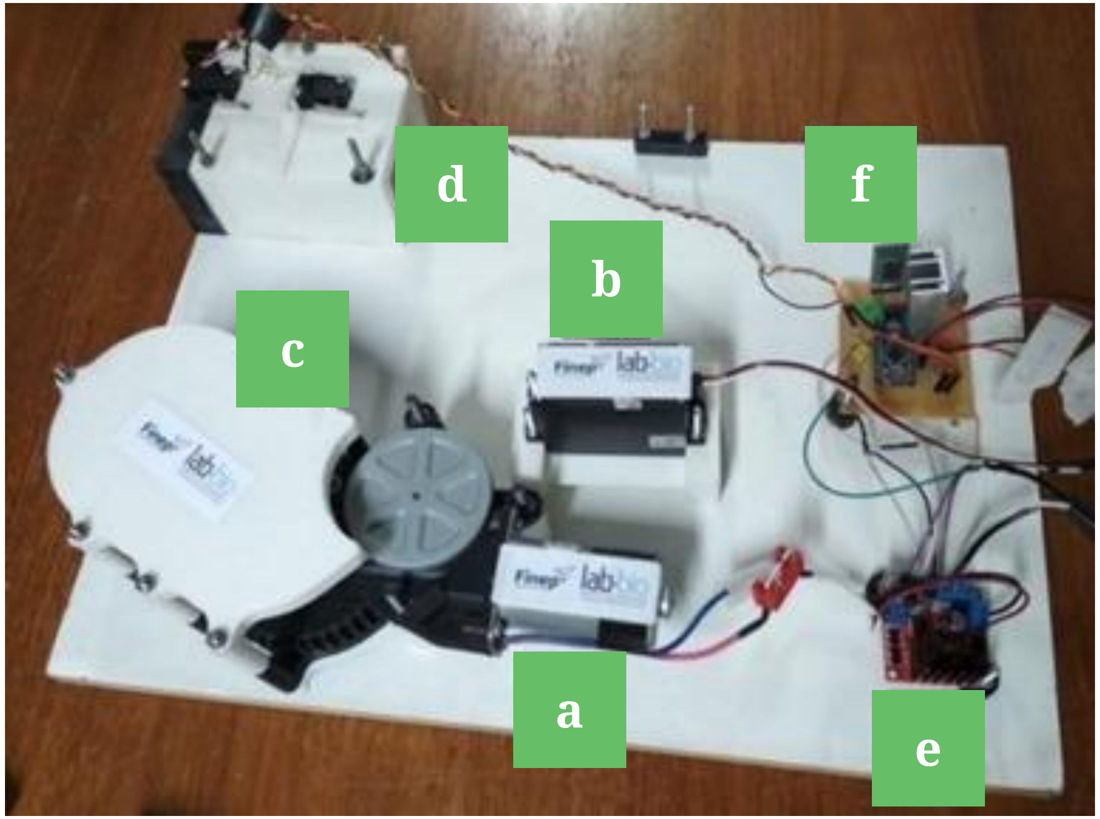


Figure 13. motors and electronics responsible for the control [1].

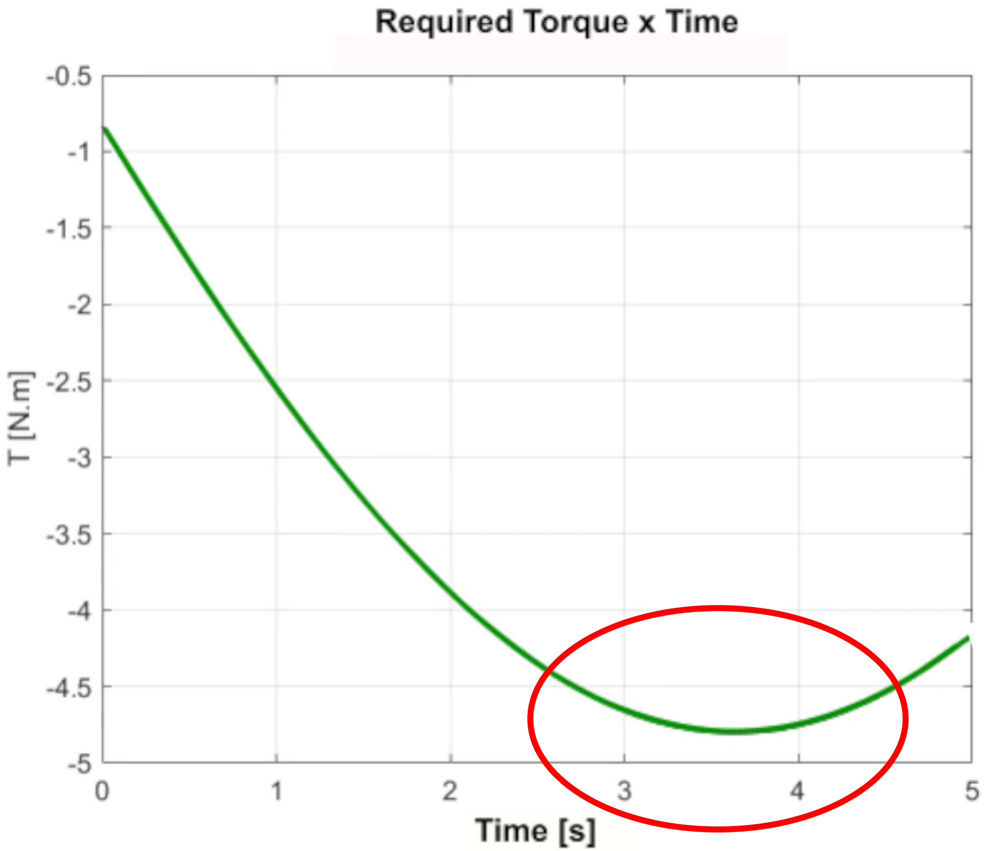
- a → DC motor
- b → Servomotor
- c → Reduction gearbox
- d → Limit switches
- e → DC Motor H bridge
- f → Controller

Experiments

MOTORS AND CONTROL

$$T_o = P \cdot R_g \cdot \sin\theta$$

- θ: elbow joint angle
- R_g: distance between the elbow joint center and center of gravity of the set
- P: weight force
- T_o: required torque to flex the elbow



Experiments

MOTORS AND CONTROL

Experiments

CLINICAL TEST

Volunteers → Research Ethics Committee (COEP) - CAAE Registry: 22207213.5.0000.5149

Table 1. Participants characteristics

Participants	Sex	Age	Dominance	Post stroke time	Spasticity Level	
					Fingers	Elbow
1	Male	73	Right	53 months	1	1
2	Male	38	Right	113 months	2	2
3	Female	25	Left	48 months	2	2
4	Female	48	Right	24 months	1	1+

Experiments

CLINICAL TEST - PROCEDURES

Results

Hand opening tests

Elbow movement tests

Results

Grabbing a water bottle task

Grabbing a ball task

Discussion

- Perform the movements effectively
- The fingers interfered with each other
- The elbow module presented relative difficulty in performing

Old configuration

Figure 9. Orthosis: old configuration [1].

New configuration

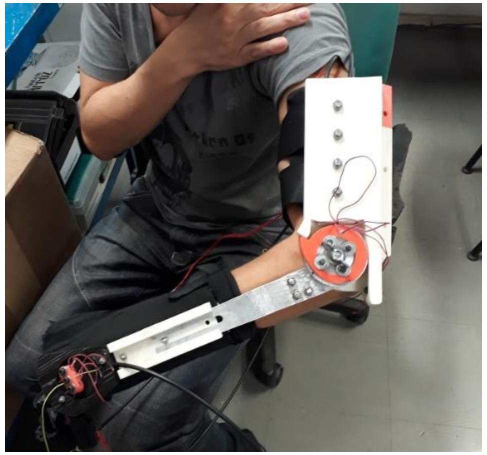


Figure 10. Orthosis: new configuration [1].

Discussion

- The excessive weight of the elbow module
- Clinical test
- Proper alignment between the exoskeleton and the user's anatomical joints

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Conclusions

- Correct biomechanical functioning
- Prototype effectiveness and safety
- Improve the mechanical structure of the orthosis
- Long-term effect

References

1. Personal file of the authors.
2. Rúbio, G. de P.; Ferreira, F.; de Lisboa Brandão, F.H.; Machado, V.; Tonelli, L.; Kozan, R.F.; Vimieiro, C. Design of Actuators Applied to a Upper Limb Orthosis. In Proceedings of the Proceedings of the 25th International Congress of Mechanical Engineering; ABCM, 2019.

Acknowledgments

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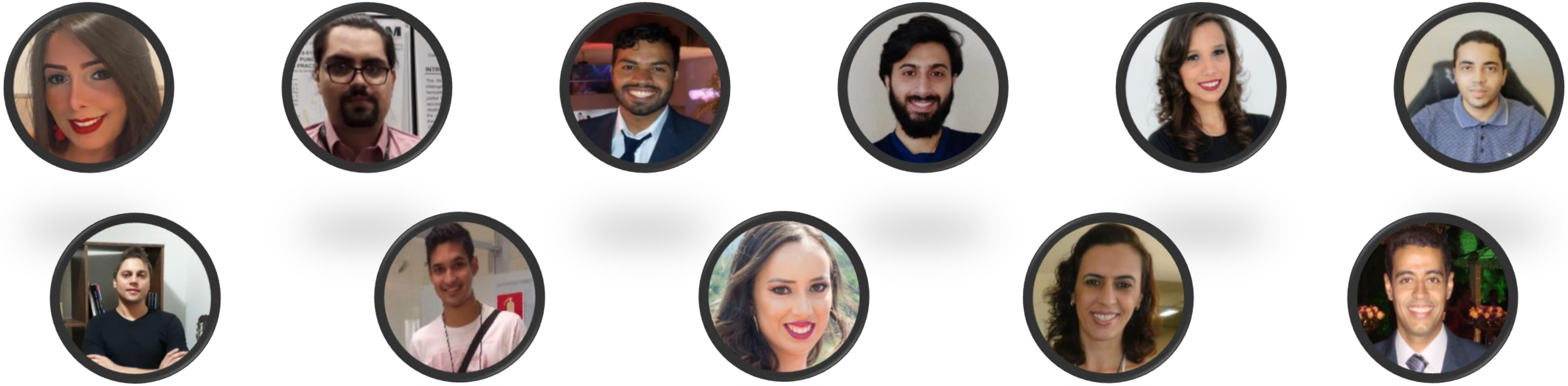

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