## Biomecanica

### Yang et al 2020

Yang, X., Lim, Z., Jung, H., Hong, Y., Zhang, M., Park, D., & You, H. (2020). Estimation of finite finger joint centers of rotation using 3D hand skeleton motions reconstructed from CT scans. *Applied Sciences*, *10*(24), 9129.

* “Digital human hand models have been widely used in ergonomic product design and evaluation”
* “the assumption that the hand is a rigid linkage system,”
* “metacarpophalangeal (MCP), proximal interphalangeal (PIP), and distal interphalangeal (DIP) joints “

### Chen chen et al 2011

Chen Chen, F., Favetto, A., Mousavi, M., Ambrosio, E., Appendino, S., Manfredi, D., ... & Bona, B. (2011, July). Human Hand: Kinematics, Statics, and Dynamics. In *41st International Conference on Environmental Systems* (p. 5249).

* “Sections 4 to 6 present data about forces, torque, velocities and power”
* “The human hand is composed of…”

### Kargov et al 2004

Kargov, A., Pylatiuk, C., Martin, J., Schulz, S., & Döderlein, L. (2004). A comparison of the grip force distribution in natural hands and in prosthetic hands. *Disability and Rehabilitation*, *26*(12), 705-711.

* “Comparison of grip in natural and prosthetic hands …”

### Fourie 2017

Fourie, R., & Stopforth, R. (2017). *The mechanical design of a biologically inspired prosthetic hand, the touch hand 3* (pp. 38-43). IEEE.

* “1.1.1.8 Finger and hand antropometry data: …”

## RCM

### Diagrama Descripción generada automáticamenteZhang et al 2019, 2014

Zhang, F., Lin, L., Yang, L., & Fu, Y. (2019). Design of an active and passive control system of hand exoskeleton for rehabilitation. *Applied Sciences*, *9*(11), 2291.

* “the SPRM [symmetric pinion and rack mechanism ] and the parallel mechanism, which can realize the telecentric motion around the joint center”

### Imagen que contiene persona, foto, mano, secadora Descripción generada automáticamenteHernández-Santos et al, 2021

* “Table 1 presents a comparative review of exoskeletons developed for hand rehabilitation. Not all of the exoskeletons can be applied effectively to daily life, e.g., only a few can

be used alone without a large drive device. Some are too complex, bulky, and unwearable,

with many active DOF, or are too expensive for home and personal use.”

* Table 1: buena comparación

### Biouras et al, 2020

* “One of the most crucial dimensional characteristics is the thickness in the lateral areas of the fingers that is coaxial to the finger joints”
* “a wearer that has thinner and longer fingers will have more space between the fingers, which will permit the mounting of an exoskeleton”
* “[RCM] has the considerable advantage of saving a lot of space between the fingers, an essential factor to take into account when designing the orthotic shell of the exoskeleton fingers”
* “underactuated redundant linkage (URL) structure as seen in Figure 2c.The size of the mechanism is considerably larger”
* “ [URL] this design does not have the precise control of each phalange individually”
* [URL] bfewer actuators and can provide a more natural movement of the wearer’s hand due to its underactuated mechanism and the compliance of the biological hand
* “two types of cable transmission are used, namely pulley-cable transmission [39] and Bowden cable transmission [40].”
* “exoskeleton segments corresponding to the finger phalanges do not need to be controlled individually [36]. A better solution is to rely on the body’s natural compliance while actuating the exoskeleton.”

Diagrama

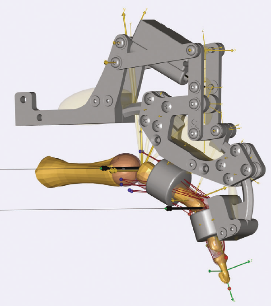
Descripción generada automáticamente

### Sandison et al, 2020 (handsome)

Un arma de fuego

Descripción generada automáticamente con confianza media

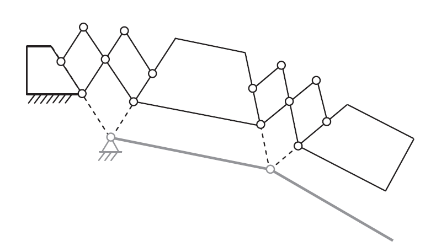
### Diez et al, 2017



### Batezzato et al 2014

* “to maintain the weight and complexity as low as possible, an only two-phalange mechanism is considered: it is a quite common solution for exoskeletons [4,18–20]”

Diagrama

Descripción generada automáticamente

### Enriquez et al 2014

* Tabla 1: rango de mvto de los dedos

Imagen que contiene interior, tabla, juguete, artículos

Descripción generada automáticamente

### Fontana et al 2013, 2009

Imagen que contiene moto, tabla, cuarto, hombre

Descripción generada automáticamente Diagrama, Esquemático

Descripción generada automáticamente

### Fang et al 2009

* “placing an exoskeleton mechanism over an operator's finger is more reasonable than beside an operator's finger. To mimic the motion of the operator’s finger, the rotation centers of exoskeleton mechanism should coincide with the rotation centers of the operator's fingers to avoid the mechanical interference”

Imagen que contiene motor

Descripción generada automáticamente Diagrama

Descripción generada automáticamente

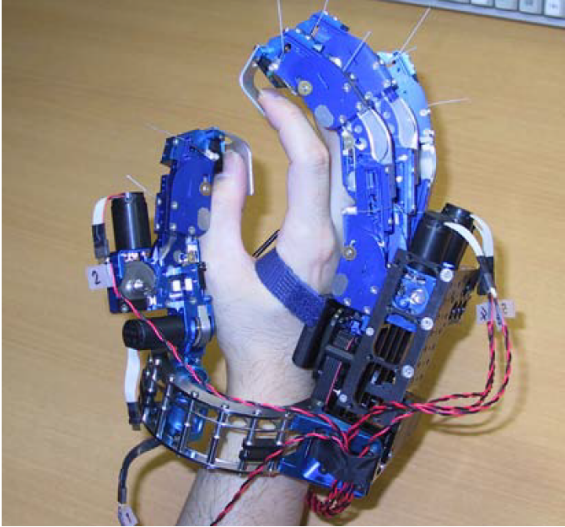
### Wang et al 2009

* Fig. 1. Biomechanical model of index finger

Diagrama, Dibujo de ingeniería

Descripción generada automáticamente

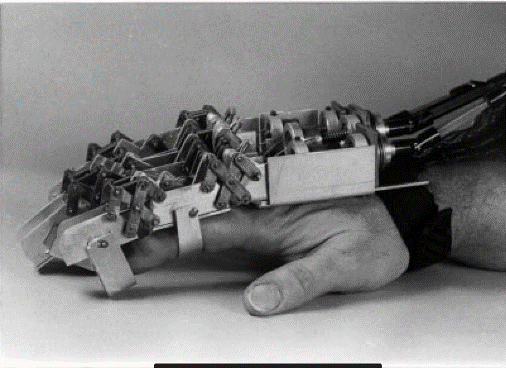
### Nakawara et al 2005

Diagrama

Descripción generada automáticamente

Shields et al 1997

* Each joint uses a four-bar mechanism to rotate about an instant center that corresponds to the instant center of the proximal phalanx with respect to ground and the middle phalanx with respect to the proximal phalanx”
* “the parallelogram structure of the mechanism the instant centers remain fixed relative to the ground link in each joint. The design of each joint mechanism was governed by having the appropriate instant centers coincide with the centers of rotation of the wearers’ fingers.”
* The kinematic coefficient relating the proximal exoskeleton link to the input link has a constant value of 1 for all three exoskeleton fingers.

 Diagrama

Descripción generada automáticamente

## Estados del Arte

### Noronha et al 2021

Noronha, B., & Accoto, D. (2021). Exoskeletal devices for hand assistance and rehabilitation: A comprehensive analysis of state-of-the-art technologies. *IEEE Transactions on Medical Robotics and Bionics*, *3*(2), 525-538.

* “namely with the development of soft and hybrid devices”

### Rosen et al 2019

Rosen, J. (Ed.). (2019). *Wearable robotics: Systems and applications*. Academic Press.

## Requerimientos

### Boser et al 2020

Boser, Q. A., Dawson, M. R., Schofield, J. S., Dziwenko, G. Y., & Hebert, J. S. (2020). Defining the design requirements for an assistive powered hand exoskeleton: A pilot explorative interview study and case series. *Prosthetics and Orthotics International*, 0309364620963943.

* differences between participants exist and identifying a universal set of criteria applicable across individuals with impaired hand function is challenging
* [in EMG measurements] The software gain was adjusted for each participant to achieve maximum eparability of signals
* Clinicians and participants with hand impairment mostly agreed on expectations for a hand exoskeleton regarding important grasp patterns, grip strength, wear time, and acceptable weight. However, responses also revealed differences in desired requirements. Some participants were more tolerant of a slower, bulkier, or louder device, so long as it was helpful, while others indicated that they would not use such a device. Most participants had some experience with rehabilitation devices that may have influenced their responses.
* *Forearm EMG.* Of the movements examined, wrist flexión and extension consistently produced the most promising EMG signals
* wrist flexor muscle, the pattern of EMG activity was indistinguishable from wrist extensión
* Seven participants: 200 g would be manageable additional weight
* 5 × 5 × 3 cm3 block too bulky
* adjustable enough that individuals could try before buying
* Must be easy to clean; ideally waterproof
* Wear the device for 6 h to a full day expressed a desire for intuitive control strategies (controlling the device with their “mind”) and an aversion to simple strategies, such as a push button
* 10 N of pinch grip force may be a reasonable goal to aim
* flex sensor on the wrist and forearm surface EMG
* myoelectric control of a hand exoskeleton is feasible, although the best control strategy for each patient type may vary
* Clinicians, who had experience with advanced control strategies, such as myoelectric control in the context of prostheses, had concerns about the reliability of these strategies.

### Randazzo et al 2017 (mano)

Randazzo, L., Iturrate, I., Perdikis, S., & Millán, J. D. R. (2017). mano: A wearable hand exoskeleton for activities of daily living and neurorehabilitation. *IEEE Robotics and Automation Letters*, *3*(1), 500-507.

* “they still suffer from an important limitation: their adoption by users on a daily basis is limited because of complexity, poor usability and high costs.”
* “we aimed at developing a device intensively usable in ADL, both for assistive and neurorehabilitative purposes”
* “tendon-driven mechanisms. These designs enable the self-alignment of the exoskeletal structure(s)”
* “natural somatosensation”
* “Table 1: Comparison of the mano device (first row) to state-of-the-art hand exoskeletons.”

### Bützer et al 2021 (RELab tenoexo)

Bützer, T., Lambercy, O., Arata, J., & Gassert, R. (2021). Fully wearable actuated soft exoskeleton for grasping assistance in everyday activities. *Soft robotics*, *8*(2), 128-143.

* literature, interviews, and usability tests with previous prototypes in subjects with euromotor hand impairments. For a better overview, we organized the requirements in two groups that typically create a difficult trade-off for assistive technology; functionality and usability in daily life (Table 1).
* palmar pinch, medium wrap, parallel extension, and lateral pinch can account for over 80% of all grasping activities executed in daily living… the thumb needs to be able to abduct and adduct, and to be used in pad opposition
* The most important points we identified for the usability in daily life include the following: Low weight and small form factor, Fast, independent donning and doffing of the device, Continuous use for the whole day, Safe user interaction, 1–2 s duration of the hand closing movement, Water resistance and cleanability, Intuitive, reliable control, Unrestricted ROM of the arm
* For RELab tenoexo, we took various decisions to optimize the trade-off between the functionality and the usability in daily life: …