




Hip Exoskeleton Market - Review of Lift Assist Wearables

Keywords:

Back Support Exoskeleton

Lower Back Support Exoskeleton

Lumbar Exoskeleton

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Goals:
Educate the Market Place

Current Best Practices:
These devices currently do not help you to lift more but should reduce fatigue, improve the lifting motion and/or assist defined tasks. There is a possibility that these systems can facilitate earlier return-to-work after an injury.

Arizona State University

wearablerobotics.com

Review of Lift Assist Wearables

Current Best Practices

These devices currently do not help you to lift more but should reduce fatigue, improve the lifting motion and/or assist defined tasks. There is a possibility that these systems can facilitate earlier return-to-work after an injury.

Application Areas:

1. **Mr. Frank Pochiro at the BMW Manufacturing group has used systems in the automotive field.**
2. **Dr. Joe Hitt at GoX Studio has developed a SmartWork Data Analytics device to measure the number and quality of lifts**
3. **Mr. Matt Marino at Briotix has studied the use of lower-back exoskeletons and postural support for use in manufacturing and logistics.**
4. **Laevo - The back support exoskeleton is used in many manufacturing and logistics plants in Europe and South America.**
5. **CYBERDYNE, Inc. - HAL for Labor Support is used at manufacturing and construction sites for assistance of lifting movements.**
6. **CYBERDYNE, Inc. - HAL for Care Support is used for transferring and bathing support of senior citizens.**

Importance

Reduce the costs of lower back pain.

Table 1: Annual Medical Costs of Work Related Lower Back Pain

Asia

H. Itoh et al., "Estimates of annual medical costs of work-related low back pain in Japan," Ind. Health, vol. 51, no. 5, pp. 524–529, 2013.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4202739/

Fujii T, Matsudaira K. Prevalence of low back pain and factors associated with chronic disabling back pain in Japan. Eur Spine J. 2013; 22(2): 432-8.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3555622/

Europe

Wenig, C. M., Schmidt, C. O., Kohlmann, T. and Schweikert, B. (2009), Costs of back pain in Germany. European Journal of Pain, 13: 280–286. doi:10.1016/j.ejpain.2008.04.005

North America

More U.S. healthcare dollars are spent treating back and neck pain than almost any other medical condition.
http://www.webmd.com/back-pain/news/20080212/86-billion-spent-on-back-neck-pain#1

Lower back pain causes more global disability than any other condition. With the ageing population, there is an urgent need for further research to better understand lower back pain across different settings.
http://ard.bmj.com/content/73/6/968

Wearable robotic systems will assist workers to lift heavy objects, palletize, and perform tasks with less fatigue. The growing field is expanding from military and rehabilitation systems to the industrial and manufacturing workspace. From industry, we are learning that there is a limited pool of younger workers combined with an older, aging workforce. Industry wants to improve the ergonomics and prevent injuries in the workforce reducing health-care costs. The goal is to "Improve the Quality of Work." For example, work related postures may lead to musculoskeletal problems such as low back pain.

This white paper will focus on hip exoskeletons that assist lifting/holding objects and moving them around.

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Figure 1

The leg structure on the left (RB3D) attaches at the waist and feet while the system on the right is form fitting (Ekso Works).

Devices are worn on the body. Some are form fitting and strapped directly to the leg. Other systems are not form fitting and do not strap to all limbs but attach at the waist and the feet. Systems may also attach at the trunk and shoulders.

Figure 2

The system on the left uses springs to hold the tool while the system on the right uses motors at the hip to assist in lifting. (System on the left Lockheed Martin FORTIS®) (System on the right ATOUN Inc.)

Devices can be passive or active. Some devices use actuators to power the joint while other systems using passive spring-like structures for gravity-balancing.

Figure 3

The system on the left is worn at the hip and back while the system on the right transfers some of the load through the exoskeleton to the ground. (System on the left CYBERDYNE, Inc.'s HAL for Labor Support) (System on the right, Ekso Works)

Devices can give torque assist to the body and/or transfer the load directly to the ground. In a system that transfers the load to the ground, the weight of a heavy tool/object is partially supported by the structure that touches the ground. In a torque assist system, the load typically is transferred through the musculoskeletal system.

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Tasks for These Systems include, but are not limited to the following:

Package Handling:

1. Handling various sizes, shapes, and weights of objects
2. Handling various objects at waist height, over the head, and on the ground
3. Handling objects in constrained environments such as aircraft containers or baggage carts
4. Lifting, Placing, Pulling, Pushing, Moving (while taking a few steps with object in your hand before placing and releasing)

Container Handling:

1. Moving aircraft containers across roller platforms and dollies
2. Pushing and pulling (individual or group of people performing a mix of these movements to accomplish correct container placement)

Manufacturing:

1. Assembling overhead
2. Assembling in a crouched positions
3. Assembling while lifting heavy objects

Tasks for Hip Robots:

1. Sit to stand
2. Squatting and the standing back up
3. How do you minimize the leaning over or lifting with the back
4. Walking or position change with heavy loads

Standards Groups focusing on Exoskeletons

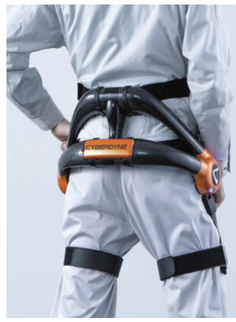
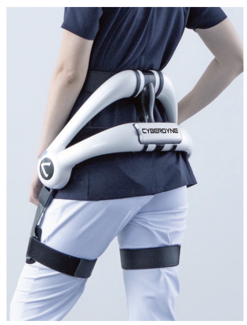
1. ISO/TC299 Robots and robotic devices
   a. WG2 Safety of Personal Care Robots (soon: Safety of Service Robots)
   b. WG4 Service Robots (Performance only)
2. ASTM F48 Exoskeletons and Exosuits

Relevant Standards on Exoskeletons

3. ISO 13482:2014 Safety requirements for personal care robots
4. JIS B 8446-2:2016 Safety requirements for personal care robots - Part 2: Low power restraint-type physical assistant robots (In Japanese English not commercially available, for additional safety requirements to ISO 13482).
5. JIS B 8456-1:2017 Personal care robots - Part 1: Physical assistant robots for lumbar support (In Japanese, for safety and performance certification with JIS mark).
6. ISO/WD 18646-4 Performance Test Methods for Wearable Robots (work in progress at ISO/TC299/ WG4)

Hip Exoskeleton Market

Review of Lift Assist Wearables

Manufacturer	Product Name	Image	Geographic Sales Location: EU - Europe, NA - North America, Asia	Purchase or Lease
CYBERDYNE, Inc.	HAL for Labor Support		Origin: Japan Current Availability: Japan Planned Availability: USA, EU (Germany)	Lease
CYBERDYNE, Inc.	HAL for Care Support		Origin: Japan Current Availability: Japan Planned Availability: USA, EU (Germany)	Lease
Innophys	Muscle Suit		Origin: Japan Current Availability: Japan	
ATOUN Inc. (formerly ActiveLink)	Model A		Origin: Japan Current Availability: Japan	Purchase
Hexar			Origin: Korea Current Availability: Korea	

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Manufacturer	Product Name	Image	Geographic Sales Location: EU - Europe, NA - North America, Asia	Purchase or Lease
Lockheed Martin	FORTIS®		Origin: U.S.A. Current Availability: U.S.A.	Purchase
SuitX (formerly US Bionics)	MAX		Origin: U.S.A. Current Availability: U.S.A.	Purchase
Ekso Bionics	Ekso Works		Origin: U.S.A. Current Availability: U.S.A.	Purchase
RB3D	Hercule		Origin: France Current Availability: Europe	
Sarcos	Guardian™ XO®		Origin: U.S.A.	Lease

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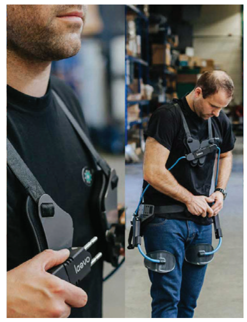
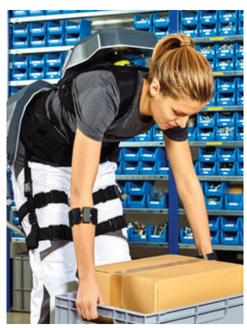
Manufacturer	Product Name	Image	Geographic Sales Location: EU - Europe, NA - North America, Asia	Purchase or Lease
Laevo	Laevo 2.5		Origin: Netherlands Current Availability: Worldwide	Purchase
Kubota	WIN-1 Power Assist Suit		Origin: Japan Current Availability: Japan	
German Bionic Cray X			Origin: Germany Current Availability: Europe	

Human Modeling Software

For some of these hip exoskeletons, human modeling software has been used to predict performance. These tools might have the potential to derive muscle forces and joint loads which cannot be easily measured.

Acknowledgements

Authors that helped contribute to the document:

Roger Bostelman
National Institute of Standards and Technology, NIST

Appendix

Organizations focusing on Exoskeletons

1. COST Action, www.wearablerobots.eu
2. WearRA, www.wearablerobotics.com
3. IEEE RAS TC Committee on Wearable Robotics
4. JARA, Japan Robotics Association

Academic Groups with Prototypes (not exhaustive list)

1.	ASU, USA	Dr. Tom Sugar - HeSA Hip Exoskeleton
2.	Vanderbilt Univ., USA	Dr. Michael Goldfarb – medical leg system
		Dr. Karl Zelik
3.	Instituto Italiano di Tecnologia (IIT), Italy	Robo-Mate EU Consortium, Hip Exoskeleton
4.	Fraunhaufer IPA, Germany	Arm exoskeleton Dr. Urs Schneider
5.	AIST, Japan	Hip Exoskeleton
6.	Virginia Tech, USA	Dr. Alan Askbeck working with Lowes
7.	Univ. of Hokkaido, Japan	Prof Tanaka
8.	Tokyo Univ. of Science, Japan	Prof. Kobayashi

Industrial Companies with Prototypes (not exhaustive list)

1. Toyota, Japan
2. Hyundai, South Korea
3. Samsung, South Korea
4. Mitsubishi, Japan
5. Kawasaki, Japan
6. Daewoo, South Korea
7. Iuvo, Italy

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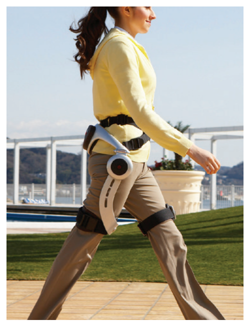
Other Related Exoskeletons

Manufacturer	Device Name and Primary Use	Image	Geographic Sales Location: EU - Europe, NA - North America, Asia
StrongArm	V22 This device is not worn at the hips.		Origin: U.S.A. Current Market: U.S.A.
Honda	Stride Management Assist Primarily used as a medical device		Origin: Japan Current Market: Japan, EU
Honda	Bodyweight Support Assist Device		Origin: Japan Current Market: N/A