Hip Exoskeleton Market -
Review of Lift Assist Wearables

Keywords:
- Back Support Exoskeleton
- Lower Back Support Exoskeleton
- Lumbar Exoskeleton

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Exoskeleton Report

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Octa Robotics

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.
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**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**

<table>
<thead>
<tr>
<th>Region</th>
<th>Source</th>
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</thead>
</table>

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.
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, not commercially available. For additional safety requirements to ISO 13482).
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<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Product Name</th>
<th>Image</th>
<th>Geographic Sales</th>
<th>Purchase or Lease</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Location:</strong> EU - Europe, NA - North America, Asia</td>
<td></td>
</tr>
<tr>
<td>CYBERDYNE, Inc.</td>
<td>HAL for Labor Support</td>
<td>[Image]</td>
<td>Origin: Japan</td>
<td>Lease</td>
</tr>
<tr>
<td>CYBERDYNE, Inc.</td>
<td>HAL for Care Support</td>
<td>[Image]</td>
<td>Origin: Japan</td>
<td>Lease</td>
</tr>
<tr>
<td>Innophys</td>
<td>Muscle Suit</td>
<td>[Image]</td>
<td>Origin: Japan</td>
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<tr>
<td>ATOUN Inc. (formerly ActiveLink)</td>
<td>Model A</td>
<td>[Image]</td>
<td>Origin: Japan</td>
<td>Purchase</td>
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<tr>
<td>Hexar</td>
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<td>[Image]</td>
<td>Origin: Korea</td>
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</tr>
</thead>
<tbody>
<tr>
<td>Lockheed Martin</td>
<td>FORTIS®</td>
<td><img src="image1.jpg" alt="Image" /></td>
<td>Location: EU - Europe, NA - North America, Asia</td>
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<tr>
<td>SuitX (formerly US Bionics)</td>
<td>MAX</td>
<td><img src="image2.jpg" alt="Image" /></td>
<td>Origin: U.S.A.</td>
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<tr>
<td>Ekso Bionics</td>
<td>Ekso Works</td>
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<td>Current Availability: U.S.A.</td>
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<td>RB3D</td>
<td>Hercule</td>
<td><img src="image4.jpg" alt="Image" /></td>
<td>Origin: France</td>
<td></td>
</tr>
<tr>
<td>Sarcos</td>
<td>Guardian™ XO®</td>
<td><img src="image5.jpg" alt="Image" /></td>
<td>Current Availability: Europe</td>
<td>Lease</td>
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</table>
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<tr>
<td>Laevo</td>
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<td><img src="image1" alt="Laevo 2.5" /></td>
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<tr>
<td>Kubota</td>
<td>WIN-1 Power Assist Suit</td>
<td><img src="image2" alt="WIN-1 Power Assist Suit" /></td>
<td>Origin: Japan</td>
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<tr>
<td>German Bionic</td>
<td>Cray X</td>
<td><img src="image3" alt="Cray X" /></td>
<td>Current Availability: Europe</td>
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### 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.
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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
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. Fraunhauer 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
## Other Related Exoskeletons

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Device Name and Primary Use</th>
<th>Image</th>
<th>Geographic Sales</th>
</tr>
</thead>
</table>
| StrongArm   | V22
This device is not worn at the hips. | ![](image1) | Location: EU - Europe, NA - North America, Asia |
| Honda       | Stride Management Assist
Primarily used as a medical device | ![](image2) | Origin: Japan
Current Market: Japan, EU |
| Honda       | Bodyweight Support Assist Device | ![](image3) | Origin: Japan
Current Market: N/A |