Washington State Department of Labor & Industries

Exoskeleton Advisory Committee
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Examples of Industrial Exoskeletons for Return to Work Consideration

Submitted by Matt Marino on behalf of the Exoskeleton Advisory Committee*

There is currently no existing evidence to support the use of occupational exoskeletons specifically for RTW. There is limited evidence to support the use of occupational exoskeletons. A growing body of research has found associations between certain occupational exoskeletons and reductions in metabolic cost and muscle activity for certain tasks as well as improvements in productivity and work quality. There is also research demonstrating increases in metabolic cost for other tasks, increases in muscle activity in antagonist muscles, increases in biomechanical loading in body areas not supported by the exoskeletons, reductions in range of motion, and reduced productivity as a result of their use. Due to small subject samples sizes and non-standardized methods used that do not carry over well to actual workplace environments and jobs the best conclusion we can currently draw from the research evidence is that the outcomes of using exoskeletons in the workplace are unpredictable at this time. Caution should be taken with exoskeletons until there is sufficient evidence to support them for specific applications, and at this time professional management of tactical exoskeleton deployment is recommended. The following document is intended to serve as an example of a potential process that can be used when an occupational exoskeleton is indicated for appropriate workers seeking to RTW.

This list should not be interpreted as an endorsement of any specific device.

The following list is not a complete list of all exoskeletons, but rather those that appear to be available now or soon and have potential uses in RTW applications. Not all the exoskeletons on this list are available in all countries at this time. The price listed for each of the exoskeletons is an approximate cost, and this information is not publicly available for all the devices at this time. Exoskeleton cost can change as new versions are released and as the market grows and changes. There may also be discounts available for large orders. Contact the manufacturers for a price quote.

Passive Lift Assist Hip Exoskeletons			
Manufacturer, Product Name and Website	**Photo**	**Geographic Origin**	**Applications**
SuitX BackX **http://www.suitx.com/backx**		USA	Lifting. Bending. Stooping.
Kinetic Edge Flex Lift **https://kineticedgeinc.com/**		USA	Lifting. Bending. Stooping.
Laevo v2.5 **http://www.laevo-exoskeleton.com/**		Netherlands	Lifting. Bending. Stooping.

Active (powered by battery or external source) Lift Assist Hip Exoskeletons			
Manufacturer, Product Name and Website	**Photo**	**Geographic Origin**	**Applications**
German Bionic Systems Cray X **https://www.germanbionic.com/product/**		Germany	Lifting. Bending. Stooping.
Cyberdyne HAL Lumbar Type for Labor Support **https://www.cyberdyne.jp/english/products/Lumbar_LaborSupport.html**		Japan	Lifting. Bending. Stooping.

Active (powered by battery or external source) Lift Assist Hip Exoskeletons			
Manufacturer, Product Name and Website	**Photo**	**Geographic Origin**	**Applications**
Cyberdyne HAL Lumbar Type for Care Support **https://www.cyberdyne.jp/english/products/fl05.html**		Japan	Lifting. Bending. Stooping. Lifting patients. HAL Lumbar Type for Care Support is designed to mitigate risks of back pain by reducing the stress that will be applied on the back. HAL will make daily care work easier and support both care givers and care receivers.
Innophys Muscle Suit **https://innophys.jp/**		Japan	Lifting. Bending. Stooping.
ATOUN Inc. Model A (formerly ActiveLink, formerly Panasonic?) **http://atoun.co.jp/**		Japan	Lifting. Bending. Stooping.

Active (powered by battery or external source) Lift Assist Hip Exoskeletons			
Manufacturer, Product Name and Website	**Photo**	**Geographic Origin**	**Applications**
Kubota WIN-1 Power Assist Suit		Japan	Lifting. Bending. Stooping.

Passive Shoulder Exoskeletons			
Manufacturer, Product Name and Website	**Photo**	**Geographic Origin**	**Applications**
Levitate AIRFRAME **http://www.levitatetech.com/**		USA	Repetitious and/or static work above shoulder level.
SuitX ShoulderX **http://www.suitx.com/shoulderx**		USA	Repetitious and/or static work above shoulder level.
Ekso Bionics EksoWorks EksoVest **https://eksobionics.com/eksoworks/**		USA	Repetitious and/or static work above shoulder level.

Passive Shoulder Exoskeletons			
Manufacturer, Product Name and Website	**Photo**	**Geographic Origin**	**Applications**
Ottobock PAEXO **https://briotix.box.com/s/fl4afnmoqkoez3152gqh98uvbf5uxgkq**		Germany	Repetitious and/or static work above shoulder level.
Comau MATE **https://www.comau.com/EN/our-competences/robotics/Exoskeleton**		Italy	Repetitious and/or static work above shoulder level.
Skelex **http://www.skel-ex.com/#**		Netherlands	Repetitious and/or static work above shoulder level.
Exhauss Model A Assembler **http://www.exhauss.com/fr_modelea.htm**		France	Repetitious and/or static work above shoulder level. Model A is particularly suitable for chain workers with repetitive gestures, assembly, packaging, integration of subassemblies, etc.

Active (powered by battery or external source) Shoulder/Upper Body Exoskeletons			
Manufacturer, Product Name and Website	**Photo**	**Geographic Origin**	**Applications**
Hexar HL 35 **http://hexarsystems.com/new/product/product_p04.php?p_idx=6**		Korea	Carrying. Upper body work.

Passive and Active (powered by battery or external source) Tool Holding and Load Re-Distributing Full Body Exoskeletons			
Manufacturer, Product Name and Website	**Photo**	**Geographic Origin**	**Applications**
Sarcos Guardian XO **https://www.sarcos.com/products/guardian-xo/**		USA	Heavy manual material handling. Handling loads up to 200lbs.
Ekso Bionics EksoWorks EksoZeroG **https://eksobionics.com/eksoworks/** (Not really an exoskeleton. Mounted to a stable structure. See below for wearable version.)		USA	Holding heavy tools. Fatigue reduction.
Ekso Bionics EksoWorks **https://eksobionics.com/eksoworks/**		USA	Lifting. Holding heavy tools. Fatigue reduction.

Passive and Active (powered by battery or external source) Tool Holding and Load Re-Distributing Full Body Exoskeletons			
Manufacturer, Product Name and Website	**Photo**	**Geographic Origin**	**Applications**
Lockheed Martin FORTIS **https://www.lockheedmartin.com/en-us/products/exoskeleton-technologies/industrial.html**		USA	Lifting. Holding heavy tools. Fatigue reduction.
SuitX MAX **http://www.suitx.com/max-modular-agile-exoskeleton** BackX – Passive ShoulderX – Passive LegX – Active Tool Holder		USA	Lifting. Bending. Stooping. Repetitious and/or static work above shoulder level. Work performed at a fixed height that is too low. Prolonged standing work with no option for sitting. Holding heavy tools. Fatigue reduction.
SuitX MAX **http://www.suitx.com/max-modular-agile-exoskeleton** BackX – Passive ShoulderX – Passive LegX – Active		USA	Lifting. Bending. Stooping. Repetitious and/or static work above shoulder level. Work performed at a fixed height that is too low. Prolonged standing work with no option for sitting.
RB3D Hercule **https://www.rb3d.com/**		France	Lifting. Carrying.

Passive Tool Holding and Load Re-Distributing Upper Body Exoskeletons			
Manufacturer, Product Name and Website	**Photo**	**Geographic Origin**	**Applications**
Exhauss Model P Picker **http://www.exhauss.com/fr_modelep.htm**		France	Holding heavy tools. Fatigue reduction. The PICKER model covers the widest possible spectrum of all operators and workers having to lift any tool or load repeatedly and with a possible weight variation from one load to another.
Exhauss Model W Worker **http://www.exhauss.com/fr_modelew.htm**		France	Holding heavy tools. Fatigue reduction. The W model is particularly intended for industrial operators having to wear the same tool all day long (riveter, perforator, pneumatic wrench) or to mount and adjust the same object (boat window, car seat, trim panel). cabin ...).
Exhauss Model C Cine-Maker **http://www.exhauss.com/fr_modelec.htm**		France	Camera gimbal handling. Holding heavy tools. Fatigue reduction. The CINE-MAKER model is intended for broadcast, cinema and independent operators, to help them wear MOVI, DJI RONIN, HELIX LETUS, ARTEMIS MAXIMA, or carry heavy camera configurations by hand.
Exhauss Model T Transporter **http://www.exhauss.com/fr_modelet.htm**		France	Holding heavy tools. Fatigue reduction. The T-Model covers a broad spectrum of all operators and workers having to move loads of varying weight across a logistic platform, plant or environment or pallet truck or devil would be too cumbersome or unusable.

Passive Tool Holding and Load Re-Distributing Upper Body Exoskeletons			
Manufacturer, Product Name and Website	**Photo**	**Geographic Origin**	**Applications**
Exhauss Model H Hanger **http://www.exhauss.com/fr_modeleh.htm**		France	Holding heavy tools. Fatigue reduction. The H model is suitable for the suspension of the work tool or the load of the mobile operator.
StrongArm Technologies V22 Ergoskeleton **https://www.strongarmtech.com/products#v22**		USA	Lifting. Carrying.

Passive Postural Support Exoskeletons			
Manufacturer, Product Name and Website	**Photo**	**Geographic Origin**	**Applications**
Levitate AIRFRAME **Head and Neck Support Device** **http://www.levitatetech.com/**		USA	Repetitious and/or static neck flexion (looking down).
Levitate AIRFRAME **Head and Neck Support Device** **http://www.levitatetech.com/**		USA	Repetitious and/or static neck extension (looking up).
StrongArm Technologies FLx Ergoskeleton **https://www.strongarmtech.com/products#flx**		USA	Postural support and tactile cueing for body mechanics.

Passive Knee/Lower Extremity and Chair-less Chair Exoskeletons			
Manufacturer, Product Name and Website	**Photo**	**Geographic Origin**	**Applications**
Noonee Chair-less Chair **http://noonee.com/#**		Switzerland/ Germany	Work performed at a fixed height that is too low. Prolonged standing work with no option for sitting.
Wearable Chair Archelis **https://www.archelis.com/**		Japan	Work performed at a fixed height that is too low. Prolonged standing work with no option for sitting.
Spring Loaded Technology Levitation Knee Brace and Offloader Add-on **https://springloadedtechnology.com/**		USA	Any activity involving the need for knee extension: squatting, lunging, work below the waist

Passive Knee/Lower Extremity and Chair-less Chair Exoskeletons			
Manufacturer, Product Name and Website	**Photo**	**Geographic Origin**	**Applications**
Astro XO Exoskeleton		USA	ASTRO XO™ is recommended for patients who suffer from gait related pain and issues such as plantar fascia injury that may cause symptoms such as limping or inability to participate in physical activities.

Active (powered by battery or external source) Knee/Lower Extremity and Chair-less Chair Exoskeletons			
Manufacturer, Product Name and Website	**Photo**	**Geographic Origin**	**Applications**
SuitX LegX **http://www.suitx.com/legx**		USA	Work performed at a fixed height that is too low. Prolonged standing work with no option for sitting.
Honda Bodyweight Support Assist **http://asimo.honda.com/innovations/feature/body-weight-support-assist/**		Japan	Work performed at a fixed height that is too low. Prolonged standing work with no option for sitting.

Active (powered by battery or external source) Exoskeletons for the Hands: Power Gloves			
Manufacturer, Product Name and Website	**Photo**	**Geographic Origin**	**Applications**
Bioservo Carbonhand **https://www.bioservo.com/sv/halso-sjukvard**		Sweden	Forceful, repetitious and/or static work with the hands.
Bioservo Ironhand **http://www.bioservo.com/industry/ironhand/**		Sweden	Forceful, repetitious and/or static work with the hands.

Active (powered by battery or external source) Exoskeletons for Ambulation (Walking)			
Manufacturer, Product Name and Website	**Photo**	**Geographic Origin**	**Applications**
Honda Stride Management Assist **http://asimo.honda.com/innovations/feature/body-weight-support-assist/**		Japan	Walking. Honda's Stride Management Assist device is designed to help those with weakened leg muscles but who are still able to walk. A motor helps lift each leg at the thigh as it moves forward and backward. This lengthens the user's stride, making it easier to cover longer distances at a greater speed.

Active (powered by battery or external source) Exoskeletons for Ambulation (Walking)			
Manufacturer, Product Name and Website	**Photo**	**Geographic Origin**	**Applications**
HAL for Well-Being Lower Limb Type **https://www.cyberdyne.jp/english/products/fl05.html**		Japan	Walking. HAL for Well-Being Lower Limb Type Pro is a wearable robot designed for inducing the improvement of the physical function in the lower limb, for the wearer in chronic stages.

*The Exoskeleton Advisory Committee is:

Stephen Bao, PhD, CPA, CCPE, Labor & Industries, SHARP

Kendra Betz, MSPT, ATP, National Center for Patient Safety, Veterans Affairs

William Billotte, PhD, National Institute of Standards and Technology, Vice Chairman ASTM F48 Committee on Exoskeletons and Exosuits

Rich Gardner, MS, PE, CPE, Boeing Research & Technology

Rick Goggins, CPE, Labor & Industries, DOSH

Pete Johnson, PhD, Occupational and Environmental Exposure Sciences, University of Washington

Jim Lin, PhD, CPE, Labor & Industries, SHARP

Matt Marino**,** PT, MSPT, CPE, CWcHP, CSCS, TSAC-F, CPT, SFMA, FMS, Briotix Health

Sarah Martin, OTR/L, Labor & Industries, Return to Work Partnerships

Keith Osborne, CEAS, CWS, Seattle City Light

Donald Peterson, PhD, College of Engineering and Engineering Technology, Northern Illinois University

June Spector, MD, MPH, Department of Environmental & Occupational Health Sciences and Medicine, University of Washington

Chris Reid, PhD, Boeing Environment Health & Safety

Ornwipa Thamsuwan, PhD, Canadian Centre for Health and Safety in Agriculture, University of Saskatchewan

Catherine Trask, PhD, Canadian Centre for Health and Safety in Agriculture, University of Saskatchewan

Delia Treaster, PhD, CPE, Ohio Bureau of Workers' Compensation