Interreg
North Sea Region
EXSKALLERATE
European Regional Development Fund
Stockholm

VINNOVA

UNIVERSITY OF GÄVLE



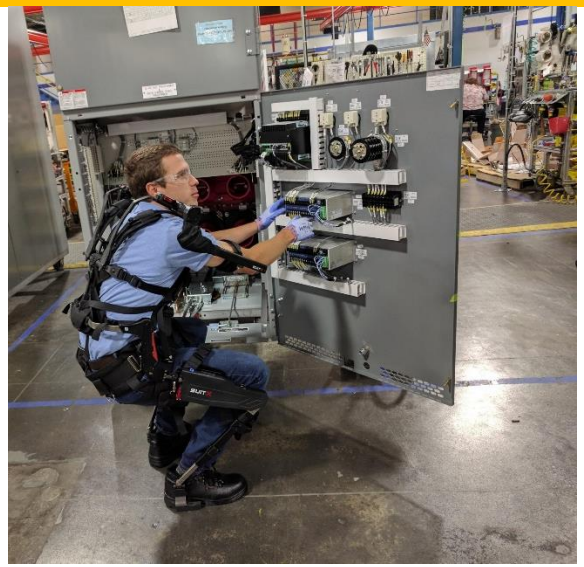


HÖGSKOLAN I GÄVLE

EXOSKELETONS RESEARCH AT HÖGSKOLAN i GÄVLE

Introduction to Exoskeletons (Exos)

- Exoskeletons are wearable devices that help users in performing different tasks with less effort.
- Exos are placed on the user's body and act as amplifiers that augment, reinforce or restore human performance.
- Exos are mainly used for military, industry and medical applications
- Exos can have passive or active actuators
- Our today's presentation will focus on Industrial applications only





Types of Exos: ACTIVE

1. ACTIVE Exos

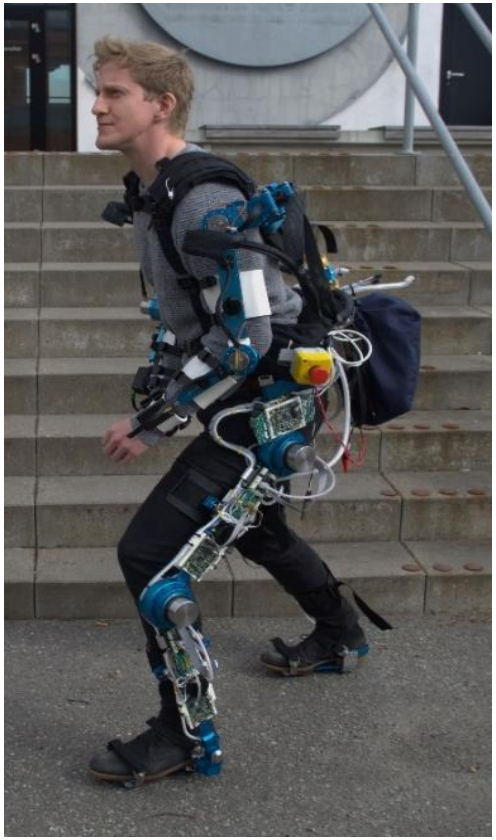
- Active Exos have powered by motors and have a lot of electronics, sensors and control system.
- Very expensive: Between US$50,000 to US$100,000

Applications of ACTIVE Exos

- Medical Rehabilitation, Military, Elderly assistance, heavy loading

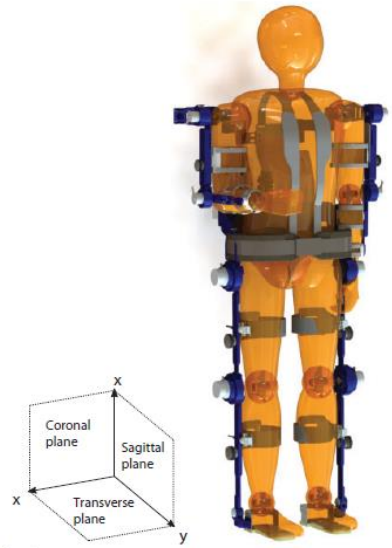
Research of University of Gävle is mainly on design & development of ACTIVE Exos

- Details is presented in later slides



AXO-SUIT Gävle & Aalbog University project

Full-body Exoskeleton research



(a)



(b)



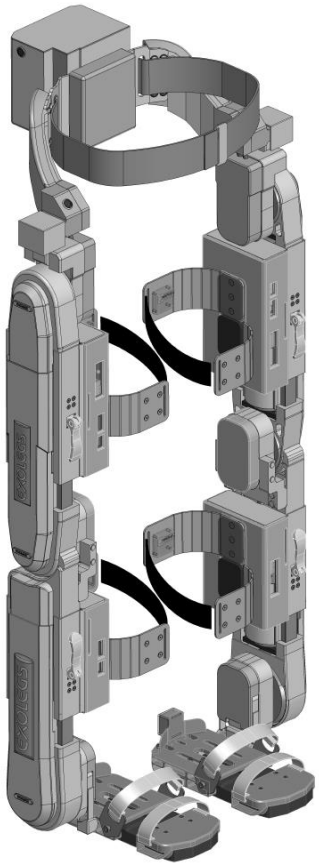
(a)



(b)

Exoskeleton Research at HiG: Design Optimization

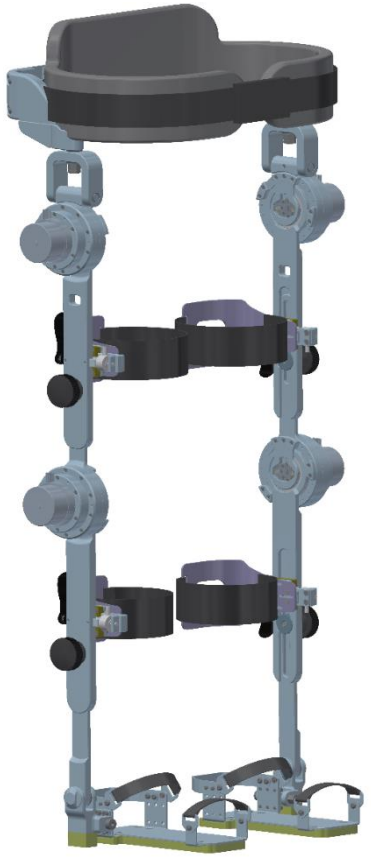
EXO-LEGS 2015
Weight ≈ 45 kg
Pre-defined trajectory based control scheme



Test-Rig: **AXO-SUIT 2016**
Weight ≈ 30 kg
Human Intention based control scheme



Prototype: **AXO-SUIT** 2018
Weight ≈ 13 kg
Human Intention based control scheme



Types of Exos: PASSIVE

2. PASSIVE Exos

- Passive Exos are mainly designed industrial & construction workers to provide assistance.
- EXSKALLERATE project mainly use passive Exos
- Simpler & cheaper: Between US$5,000 to US$10,000



Applications of PASSIVE Exos

- For workers doing repetitive loading unloading tasks.
- HiG have both upper and lower body passive exos (Details is presented in later slides)



EXSKALLERATE

Interreg North Sea Region EXSKALLERATE European Regional Development Fund

EUROPEAN UNION

Funding Agency: INTERREG (EU)

Background:

In European Union, up to 44 million workers are affected by workplace-related musculoskeletal disorders (MSDs), Fatigue and injuries representing a total annual cost of more than €240 billion.

The problem of work-related injuries and sicknesses is also affecting Sweden with its extremity.

Project Consortium: EXSKALLERATE

Total Partners = 13, Universities = 5

Commercial Companies = 8

Countries participating in the project:

1. **Norway**
2. **Sweden**
3. **Denmark**
4. **Ireland/Scotland**
5. **Germany**
6. **Netherland**
7. **Spain (as project consultant)**



Why University of Gävle in EXSKALLERATE?

Based on University of Gavle's expertise in the field of exoskeletons, we have been given the role as a,

- Accelerate adoption of exos in industry by inviting them in our lab for demo testing
- Perform real time live testing with industrial workers on their site
- Functioning Bridge between the end users (SMEs) and the existing commercial developers
- Prepare detailed design reports highlighting the technical issues in the commercial exos and suggesting design improvements

Overall Objectives: EXSKALLERATE

- To create awareness among local industry, SMEs and construction sector about the possible solutions, such as using Exoskeletons, to avoid or minimize work-related injuries.
- Large industries such as FORD, TOYOTA, AUDI, VOLVO are already using these exoskeletons
- FORD motors reported that work-related injuries are reduced by 83% after adopting the exoskeletons.
- However, the use of exoskeletons among SMEs are still not known
- Therefore, EXSKALLERATE aims to reach out to SMEs so that adoption of exoskeletons can be accelerated

Testing Phases

- There are TWO TYPES of TESTING

Phase-1

Lab Testing: at the Exoskeleton Research Lab of the University of Gävle

Phase-2

On-site Industrial Testing

Lab Testing at HiG

1. Upper Body Exo (Eksovest, by Eksobionics)

- ❑Suitable for tasks that require **lifting of the arm(s) to chest level and overhead positions**.
- ❑It has 3 Different Loading Support Modes

❑Support is increased gradually as the arm is lifted upwards. Maximum support is achieved when upper arm is approximately parallel to the ground.

❑Flexible Fittings:

(a) ≈164 cm to 195cm tall user

(b) Vast range of waist size can be adjusted

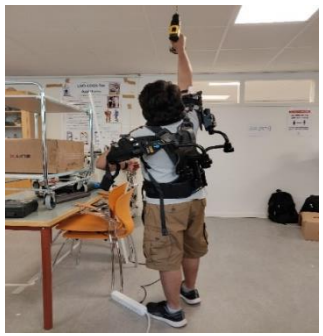
Our results showed that about 60% reduction in muscle activity was achieved when using Eksovest to perform these tasks.











Lab Testing at HiG

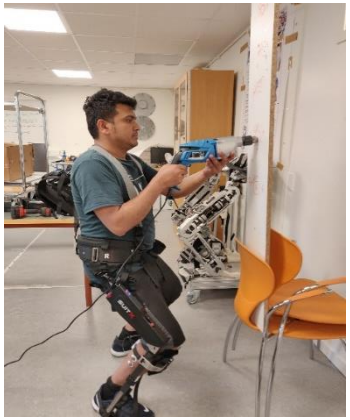
2. Lower Body Exo

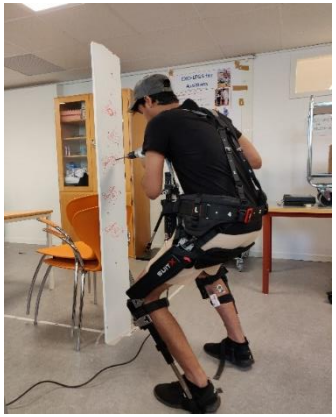
(LegX, by SUITX)

❑*LegX is a semi-passive knee exoskeleton*

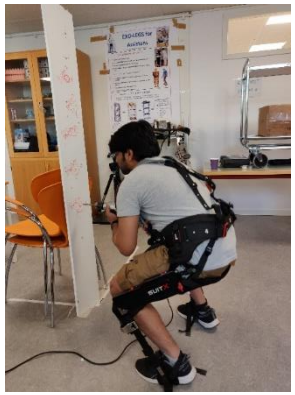
It has TWO position modes
1. Chair Position
2. Deep Squatting

❑The amount of support can be adjusted to suit the needs and weight of the user.





Chair Position


Squatting Position

Our results showed that up to 50% reduction in muscle activity was achieved when using LegX to perform these tasks.

Phase-2: Testing

On-site Industrial Testing

Exoskeleton Systems used

Names of the exoskeleton(s) tested – lower and upper back

i. ***Eksovest*** *– Upper body exoskeleton by Eksobionics*

ii. ***LegX*** *– Lower body exoskeleton by SuitX*

iii. ***BackX*** *– Upper body exoskeleton*







SMEs Information

How many SMEs have you contacted?

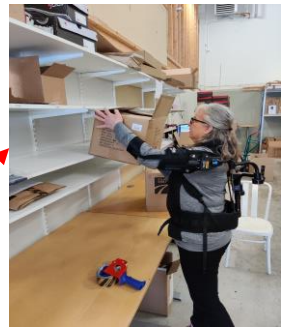
Approximately 10+ SMEs have been contacted

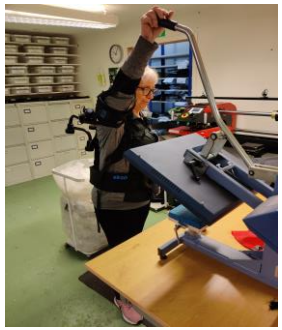
How many SMEs have replied/are interested so far?

5 SMEs shown strong interest.

SME 1: IndustriProfil - Gavle (5th Feb 2022 – 28th Feb 2022) COMPLETED

Industrial workers' Gear manufacturing/supply (Eksovest was tested)





SME 2: Takringen – Gavle (1ST March 2022 till 15th April 2022) COMPLETED

A ceiling installation company (Eksovest was tested)



SME 3 : BTT, Parse Group, Kisa (6th June 2022 till September) Recently Completed

Manufacturing Industry (Eksovest and BackX are being tested)

SME 4: Cebes, Manufacturing of Elevators (Lifts), November 2022

- *till October 2022, Eksovest & BackX would be tested*

IndustriProfil (SME)







SME Name: IndustriProfil
Area of work: Preparating Industrial gears for workers
Short Video Link:

Short Video



SME Site No.3

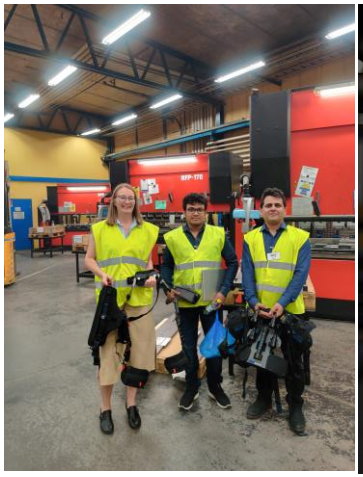
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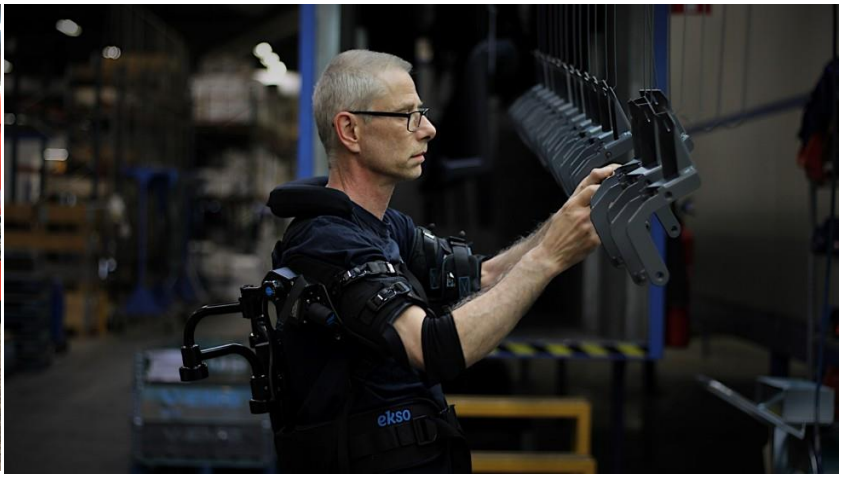
SME 3: BTT – Parse Group

- *Manufacturing Industry*
- *Dates: 6th June to September 22*

Exoskeletons tested:

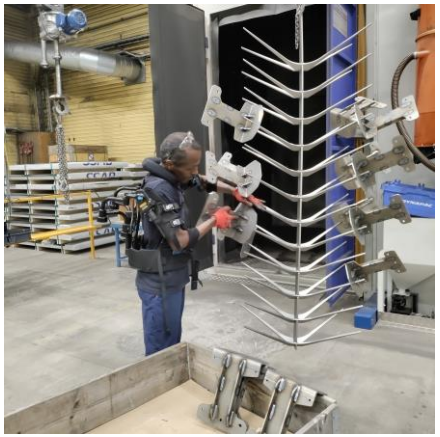
- ❖ *Eksovest*
- ❖ *BackX*











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BAX & COMPANY/

Project Milestone: Feedback to Manufacturers of Exoskeletons

Detailed design improvement document explaining modifications, sent to manufacturer:

1. *Identified extra protruded parts*
2. *Heaviness (identified heavier parts)*
3. *Balancing Issues of LegX*
4. *Wearing complexities*
5. *Human-Exoskeleton interface improvements*



Brief Results

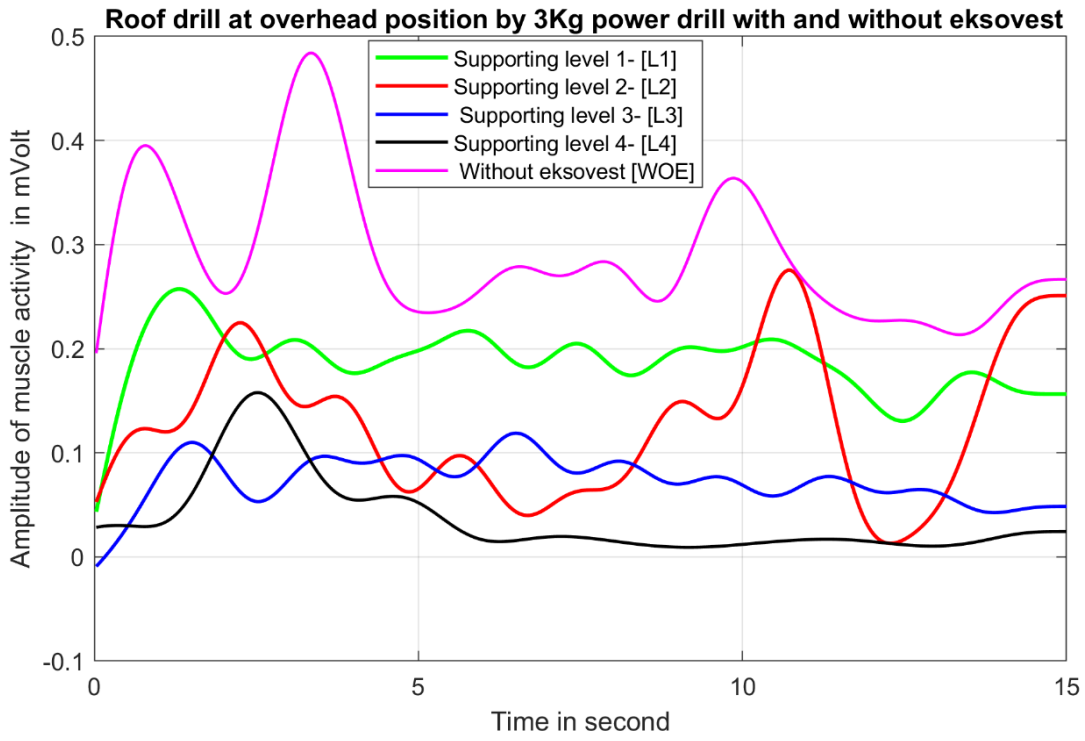
Results are presented in,

1. Graphs

2. Tables

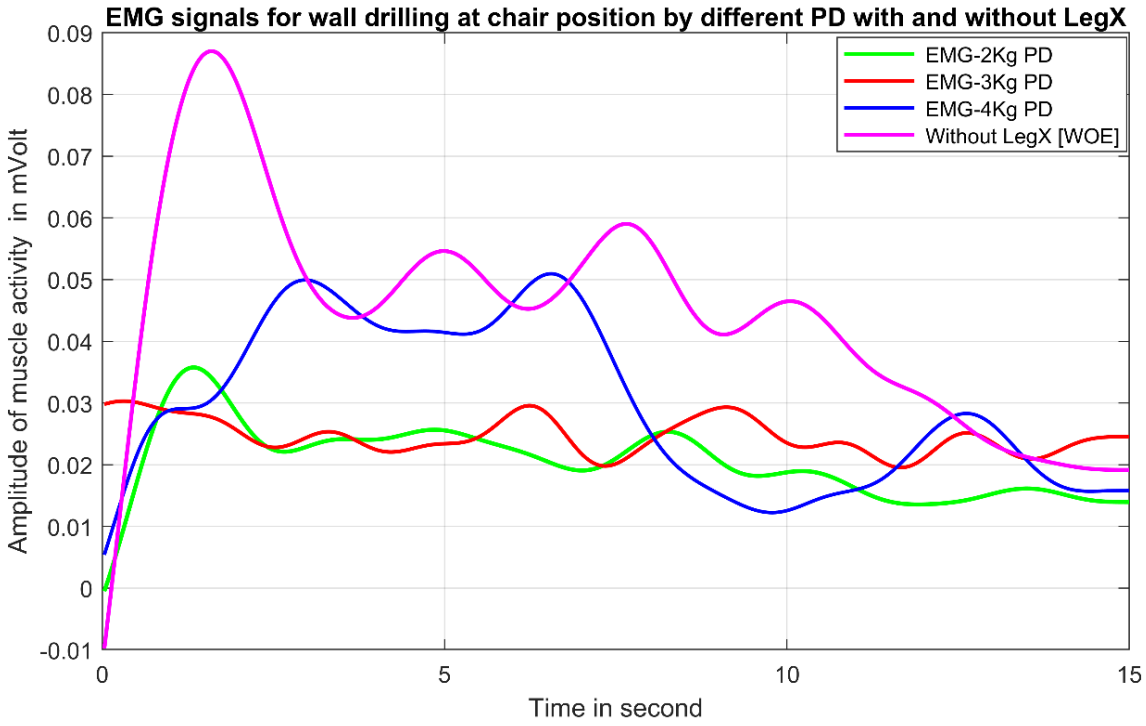
Percentage Reduction in Muscle activity is calculated and compared with and without wearing exoskeletons

Brief Results



Weight of the drill machine	Support level	%Reduction in effort
2Kg	L1	23.48%
	L2	36.56%
	L3	48.42%
	L4	61.25%
	WOE	
3Kg	L1	18.05%
	L2	34.95%
	L3	41.20%
	L4	56.25%
	WOE	
4Kg	L1	12.81%
	L2	32.31%
	L3	39.19%
	L4	54.87%
	WOE	

Brief Results: Virtual Chair Position



Wall Drilling in chair Position	Weight of power drill	%Reduction in effort
	4 Kg	37.25%
	3 Kg	47.05%
	2 Kg	50.09%

Current Status at HiG:

1. Contacting the Local SMEs, Construction and Logistics companies
2. With the help of local government, HiG will arrange trainings for rehabilitation program for workers out of worker due to injuries
3. To increase the awareness about the benefits of using exoskeletons
4. HiG team has published articles for technical magazines and newspapers of Sweden.

Thanks for your attention ☺