MARI4YARD
MARI4ALLIANCE

Exoskeletons assisting workers in outfitting & assembly tasks

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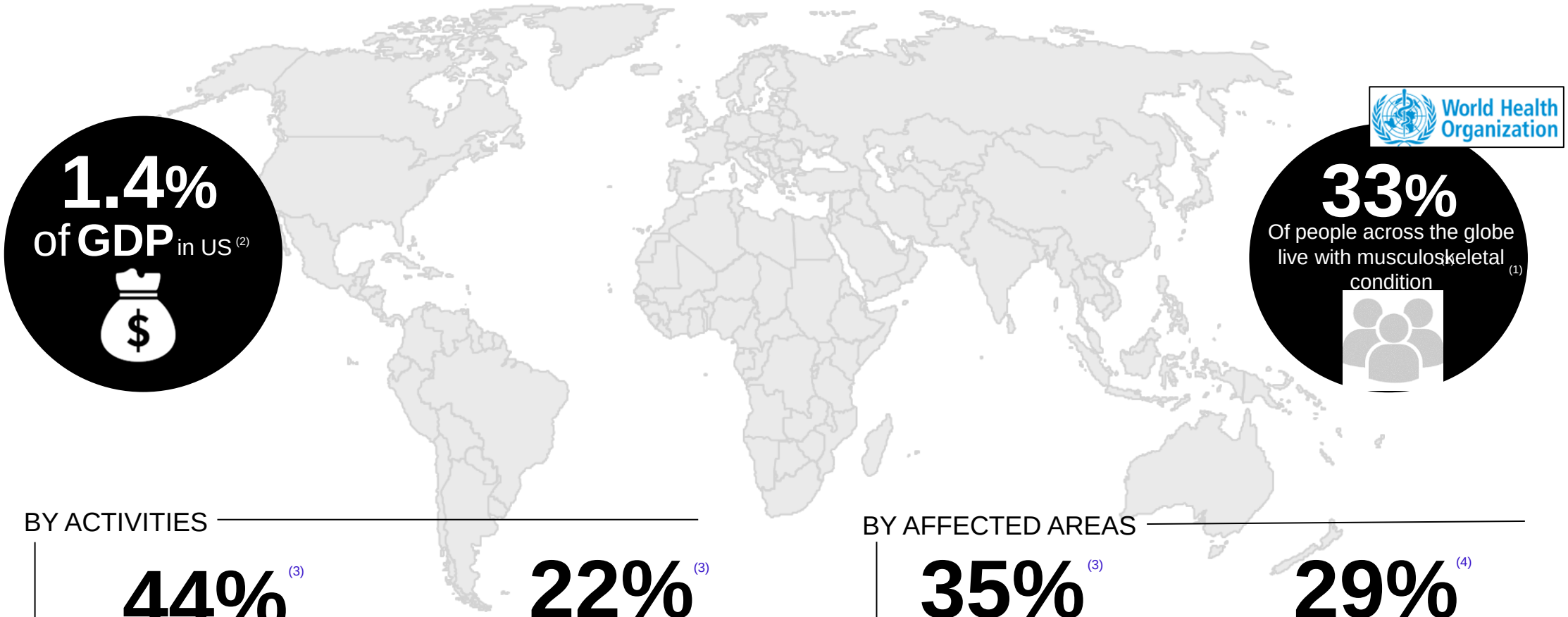
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101006798

Work-related Musculoskeletal Disorders (WRMSDs)



1.4% of **GDP** in US [2]

33% Of people across the globe live with musculoskeletal condition [1]

World Health Organization

BY ACTIVITIES

44% [3]
MANUAL HANDLING

22% [3]
AWKWARD POSTURES

BY AFFECTED AREAS

35% [3]
UPPER LIMBS

29% [4]
LUMBAR SPINAE/TRUNK

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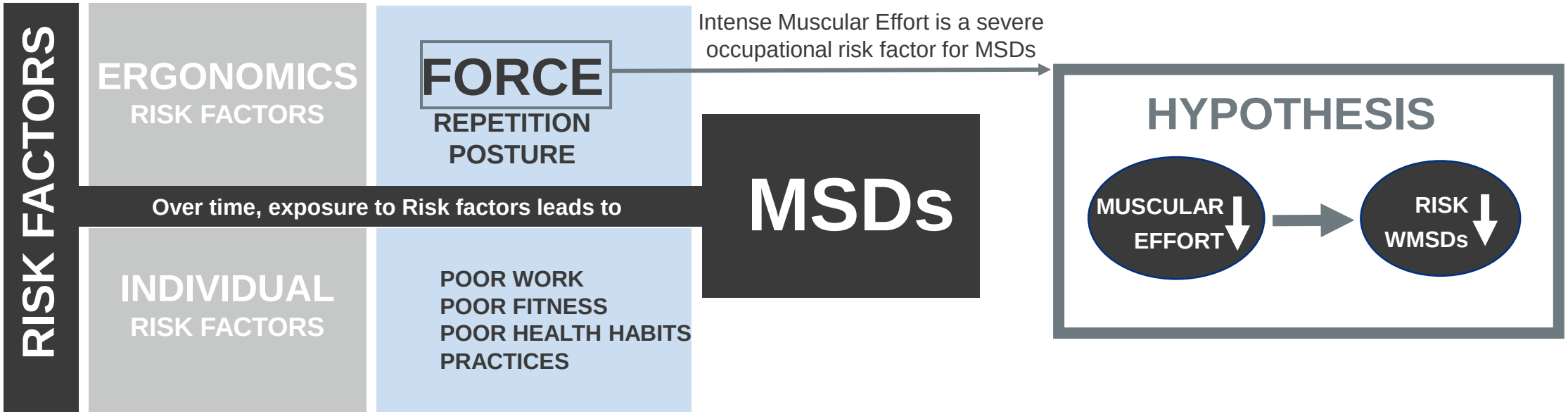
(1) World Health Organization- Data on Musculoskeletan Conditions - https://www.who.int/news-room/fact-sheets/detail/musculoskeletal-conditions
(2) The Impact of Musculoskeletal Disorders on Americans — Opportunities for Action http://www.boneandjointburden.org/docs/BMUSExecutiveSummary2016.pdf
(3) Estimated value from http://www.hse.gov.uk/statistics/causdis/msd.pdf
(4) http://www.hse.gov.uk/statistics/causdis/msd.pdf

Hypothesis driven product Design



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The present of exoskeletons for workers

Passive exoskeletons for lower-limb support

- Task: sitting, static postures
- Assistance: hip, knee, ankle, trunk

Passive exoskeletons for lumbar support

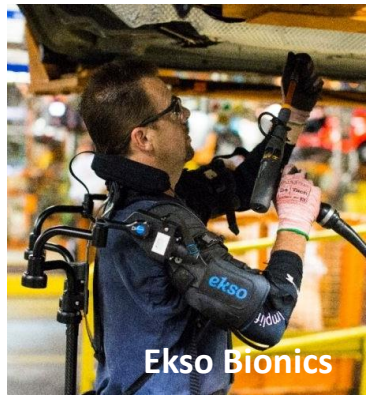
- Task: static trunk flexion
- Assistance: trunk extensor muscles

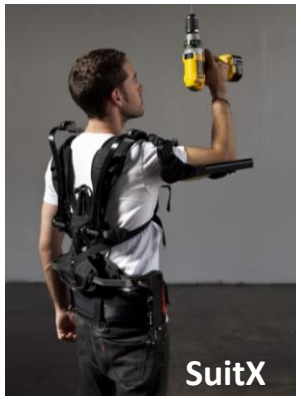
Passive exoskeletons for upper limbs

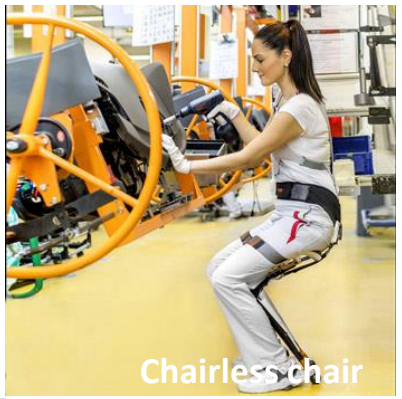
- Task: overhead manipulation
- Assistance: shoulder flexion-extension

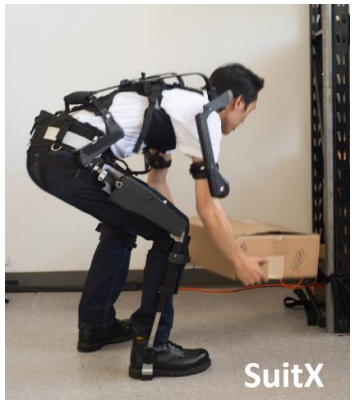
Powered exoskeletons for lumbar support

- Task: dynamic trunk flexion (e.g., lift)
- Assistance: trunk extensor/flexor muscles









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Exoskeletons assisting workers in outfitting & assembly tasks

- WP leader: IUVO
- Technical objectives
  - To develop two spring-loaded exoskeletons, to provide shipyard workers with supporting tools in upper-limb repetitive tasks and during manual handling of goods

SAFETY | **QUALITY**

Ergonomics | **Fatigue errors avoidance** | **Improved precision**

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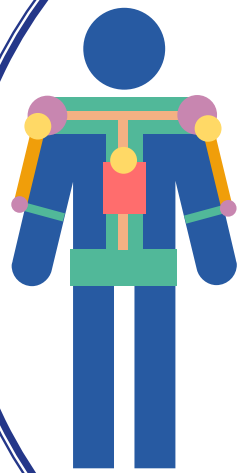
User-centric needs map

Background & IUVO experience

- Weight optimization
- Encumbrance reduction
- Size adjustments
- Physical Human-Robot interface
- Reliability
- Usability
- Autonomy

Mari4_YARD Exos



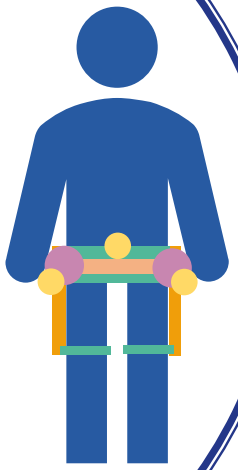
Active boxes
containing semiactive/passive mechanical assembly that generates the assistive torque

Physical Human Robot Interface (pHRI)
to properly distribute the exoskeleton reactions on suitable areas of the human body

Passive Degrees of Freedom (pDOFs)
allowing the user to perform freely his/her task

Regulations
to properly fit several body dimensions

Sensors
to monitor the internal status of the exoskeleton



Mari4_YARD project needs

- Adaptive output assistive torque
- Sensors integration
- External communication

Mari4_YARD application use case

- Targeted working tasks/production stages
- Environmental conditioning factors

Design/Manufacturing/Assembly

- Wiring
- Simplification
- Standardization

Safety/Risk assessment process

- Intrinsically safe-design
- Integrated enclosures
- Standard regulations

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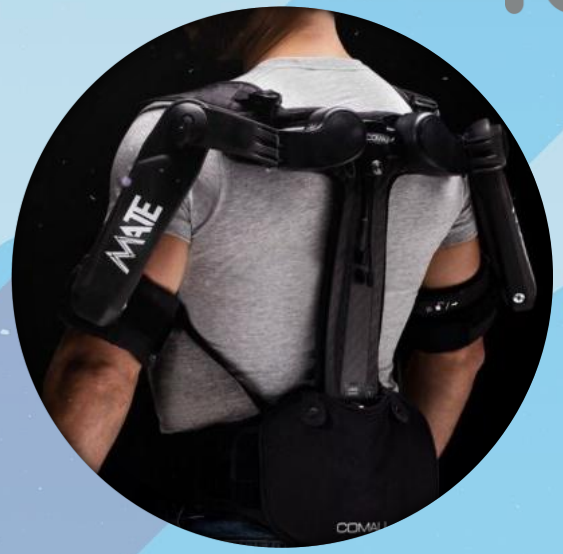
IUVO S.r.l. is a spin-off company of The **BioRobotics Institute, Scuola Superiore Sant'Anna**; it was founded on January 2015. From 2017 IUVO works with **Comau S.p.a.** and **Össur** to foster a wide adoption of wearable robotic technologies in daily-life scenarios.

Wearable Robotics
Laboratory (WR-LAB)
Prof. Simona Crea
& Prof. Nicola Vitiello

ISTITUTO DI BIOROBOTICA
Scuola Superiore Sant'Anna

IUVO develops innovative wearable robotics technologies

IUVO



COMAU

ÖSSUR

MATEXT

IUVO

COMAU

Active box

- ✓ Smart mechanism for smooth assistance
- ✓ Tuneable assistance (7 levels)
- ✓ Smart combination of simple components

Passive DOFs chain

- ✓ Effective transfer of loads
- ✓ Freedom to execute movement

pHRI

- ✓ Wearability
- ✓ Adjustability to different body sizes
- ✓ Pressure distribution
- ✓ Lumbar support and stability

What is MATEXT ?

MATEXT IS AN UPPER-LIMB EXOSKELETON

- totally passive (w/o motors)
- designed to assist the user during flexo-extension movements of the shoulder
- designed to fully support worker's arms during over-head works
- designed to follow the physiological movement of your shoulders

Shoulder Size Regulation System
It easily adjusts to workers' anthropometries wrapping the workers w/o risk of entanglement

Mechanical Shoulder Chain
Passive degrees of freedom enable dynamic alignment with shoulder muscles allowing the exoskeleton to work with the worke

Torque Generator Box
The exerted assistance follows the physiological demand according to biomechanical principles.
Variable assistance levels can be set to adapt to workers support needs

Trunk Support
It provides a solid and comfortable back support throughout the task execution also thank to its height regulation system that easily adapts to trunk size

Sliding Cuff
100% comfortable to support the workers' arms during all overhead works

Waist Belt
It quickly adjusts to abdomer circumference allowing to transfer the arm weight directly to the hips (by-passing the back)

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In a nutshell

- Adjustable Assistance
- Outdoor Resistant
- Ergonomic Certificate
- Intuitive Design
- Compact & Safe

MATEXT
FIT FOR WORKERS
WHERE DOES IT WORK? WHERE YOU DO.

Certifications

- **CE (2006/42/EC)**
- **ISO 13482:2014 (Personal Care Robot)**
- **Ergonomics EAWS**

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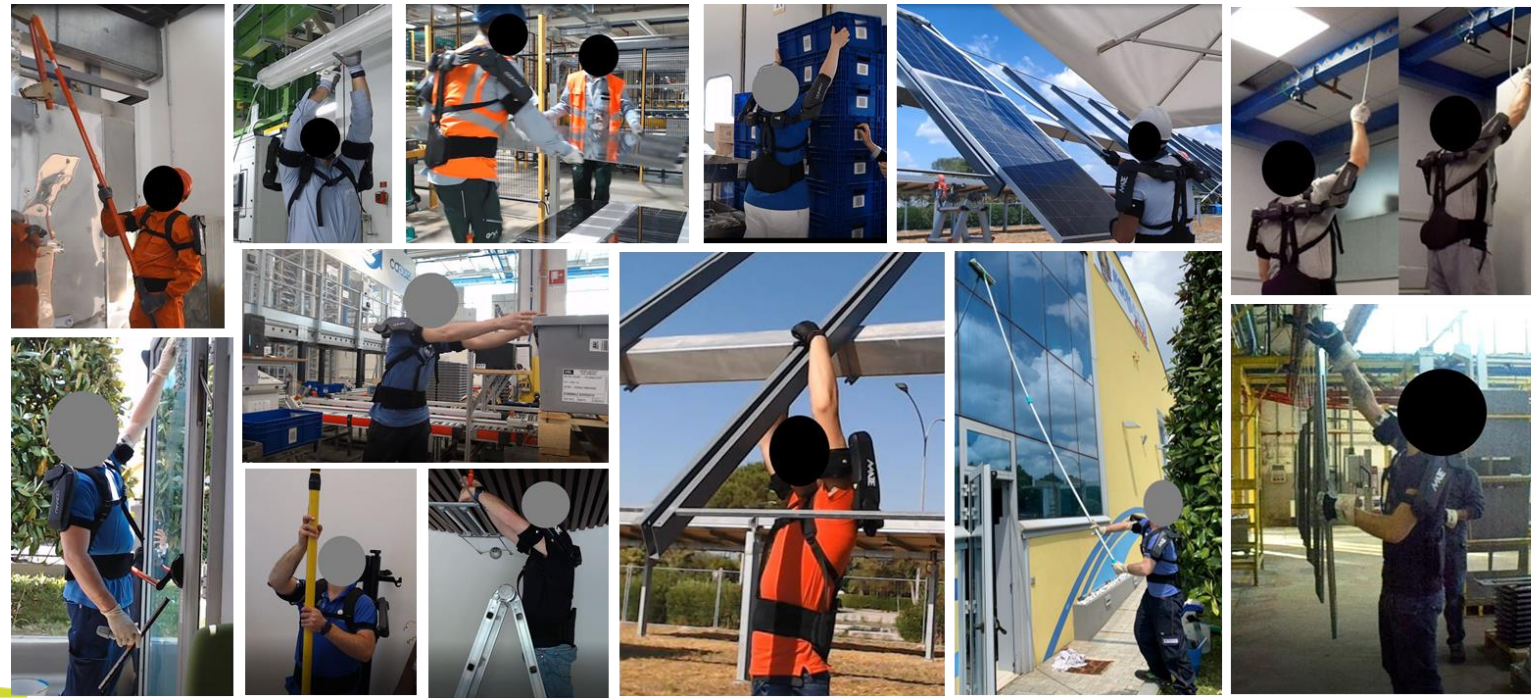
Main application areas

Where MATExT may be used

- Overhead tasks
- Repetitive tasks

- Underbody operations
- Mounting and dismounting pieces/hooks in painting area
- Enclosures production line
- Photovoltaic panels assembly
- Service provider
- Appliance assembly
- Waste collection & street cleaning
- Screwing with raised arms
- Sealing with raised arms
- Assembly operations performed with raised arms
- Cleaning with raised arms
- Painting with raised arms
- Logistics
- Manual loading / unloading
- Manual picking



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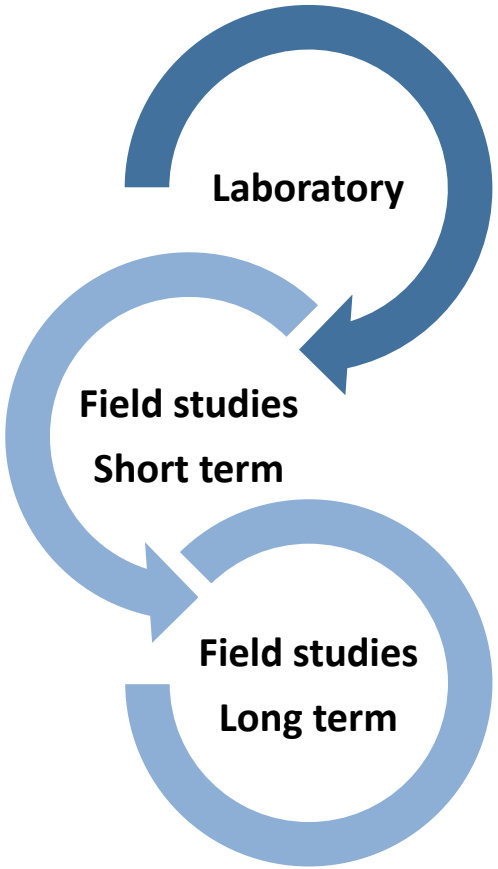
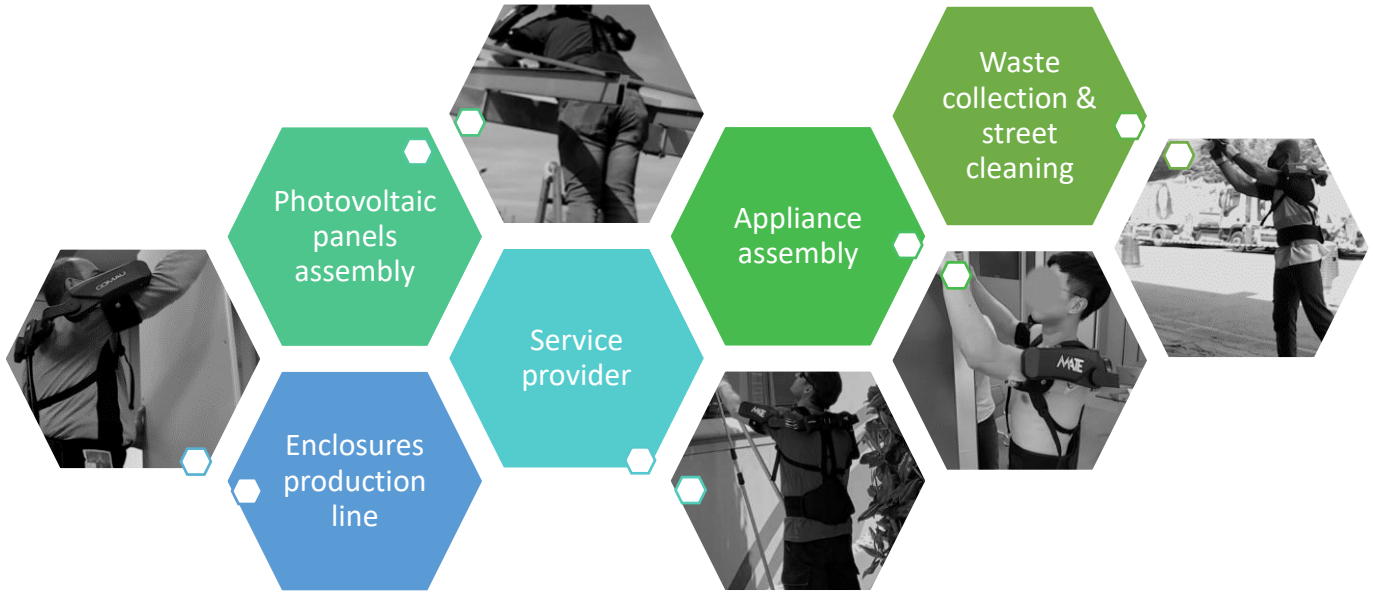
Assessment of effectiveness





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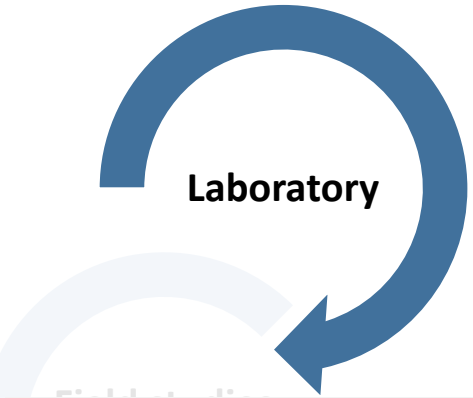
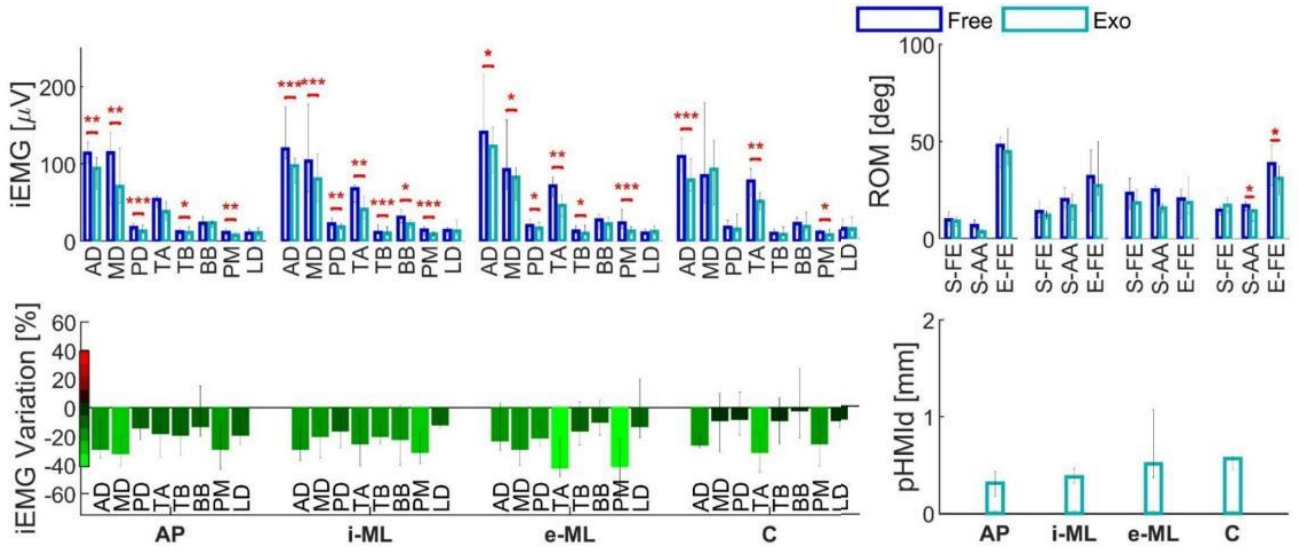


- Muscle activity
- Arm kinematics
- Stability of the human-machine interface

Objectives

- Novice participants
- Stereotyped tasks
- Instrumental metrics

Methods



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I. Pacifico et al., "An Experimental Evaluation of the Proto-MATE: A Novel Ergonomic Upper-Limb Exoskeleton to Reduce Workers' Physical Strain," in IEEE Robotics & Automation Magazine, vol. 27, no. 1, pp. 54-65, March 2020, doi: 10.1109/MRA.2019.2954105.

Assessment of effectiveness

Laboratory

Field studies

Short term

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Exoskeletons for workers: A case series study in an enclosures production line

Ilaria Pacifico [a,g,*], Andrea Parri [b], Silverio Taglione [c], Angelo Maria Sabatini [a], Francesco Saverio Violante [d,e], Franco Molteni [f], Francesco Giovacchini [b], Nicola Vitiello [a,g,h,1], Simona Crea [a,g,h,1,**]

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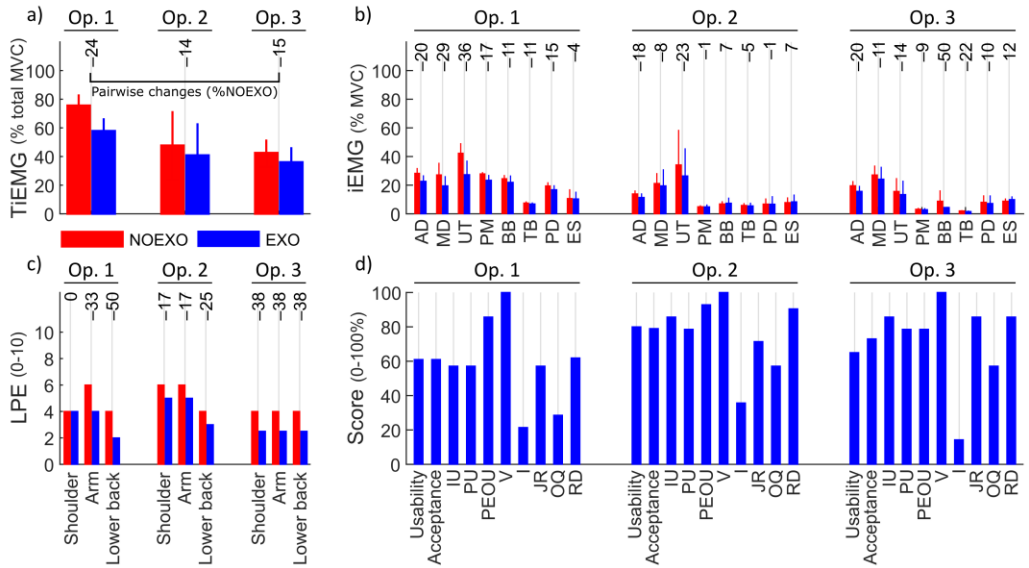
- Muscle activity
- Perceived effort & comfort

Objectives

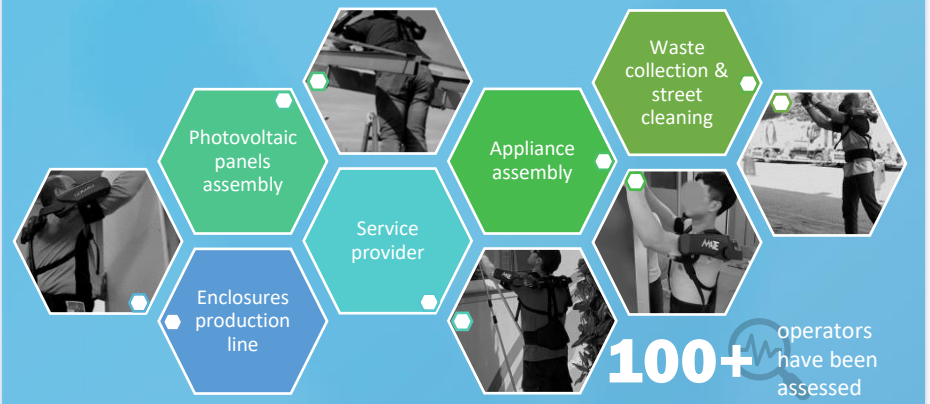
- Experienced workers
- Simulated or field tasks
- Instrumental & subjective metrics

Methods



I. Pacifico et al., "Exoskeleton for worker: a case series study in enclosures production line" in Applied Ergonomics, January 2022, doi: 10.1016/j.apergo.2022.103679

Human-centered technology assessment



The beneficial effects of using MATE have been constantly documented since the start of its development

30% ↓ **REDUCED MUSCULAR EFFORT** AT SHOULDER LEVEL

Using MATE generates a steady reduction in shoulder muscle activation during overhead activities, improving ergonomics, posture and reducing muscular strain

25% ↓ **PERCEIVED EFFORT REDUCTION** PERFORMING ACTIVITIES

Workers' perception highlighted high correlation between perceived strain reduction and the measured reduced muscular effort at the shoulder

50% OF WORKERS PERCEIVED IMPROVED POSTURE ↑ **BACK SUPPORT RELIEF**

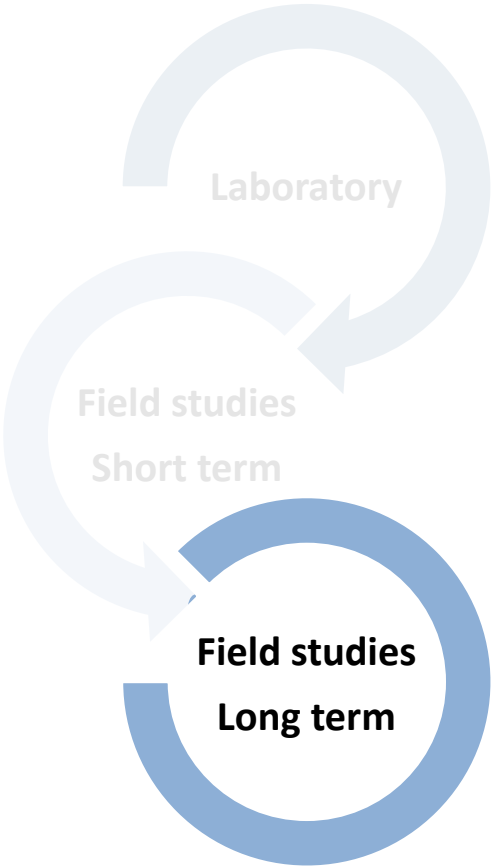
More than 50% of workers reported a beneficial upgrade of their job quality

POSITIVE IMPACT ON YOUR ERGONOMICS

fondazione ergo BELLA FACTORY. Partner of MTM ASSOCIATION

MATE is uniquely certified as an effective tool to reduce the Biomechanical overload using the new release of EAWS

Assessment of effectiveness



- Potential adverse long-term effects
- Effects on WRMSDs (?)

Objectives

- Experienced workers
- Real tasks
- Instrumental & subjective metrics

Methods

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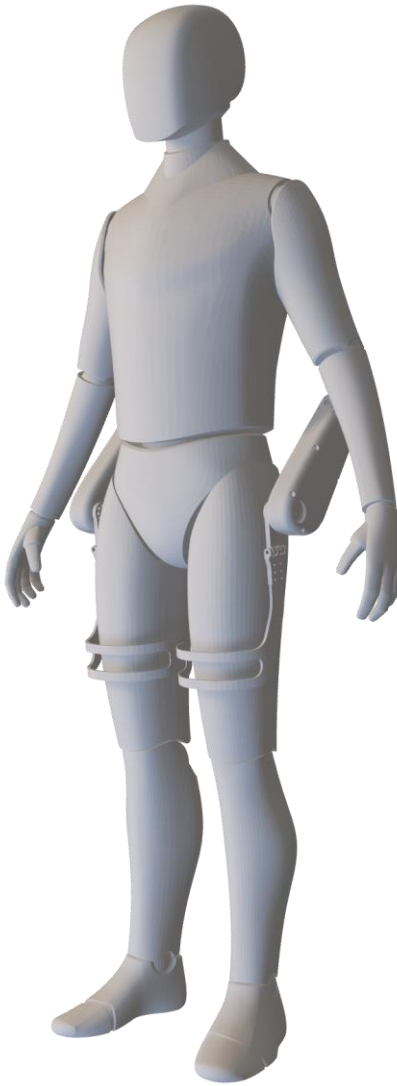
Lumbar support exoskeleton: background and future development

Active APO:

- Active exoskeleton
- Lumbar support
- explorative prototypical supporting strategies
- simulating a passive concepts toward a product development

What's Next
Passive lumbar support exoskeleton

- based on spring-loaded mechanism



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Exoskeletons in shipyard

Many working tasks and production stages are still performed by operators:

- Tanks cleaning
- Water jet cleaning
- Welding
- Other activities: ceiling cabling, painting, manual transport of weights

Shipbuilding environmental needs:

- IP encloserus
- Anticorrosion in marine environment
- Welding safety
- ATEX standards

CLEANING

80% of cleaners reports having to make repetitive movements and 50% seeks of musculoskeletal pains (european Agency for Sagfety and Helath at work – http://osha.europa.eu

WELDING

Dave Landon, 2015 American Welding Society president, believes that “exoskeleton devices can and will be part of our everyday options for PPE in the coming years” Butler T. «Exoskeleton technology: making workers safer and more productive», Professional safety, 2016

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User-centric Mari4_YARD needs

BACKGROUND:

Source for general safety requirements:

MEDICAL DEVICES - UNI CEI EN ISO 14971:2020

MACHINERY SAFETY - UNI EN ISO 12100:2010

PERSONAL CARE ROBOTS - UNI EN ISO 13482:2014

Mari4_YARD project needs:

- Sensorization
- AI-based algorithms for assistance adjustment

Shipyard environmental needs:

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Thank you for your attention!

Andrea Parri, IUVO

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