Wearable exoskeleton robots to reach a global market of US$ 5.2 billion by 2025

In recent years, new body-worn assistive devices – the so-called exoskeletons – have been introduced in the market, mainly for industrial and medical applications. Initially, they had been developed for military purposes. They include active and passive systems that enable workers in different industries to perform heavy lifting activities and work more efficiently. The benefit of reducing work-related musculoskeletal disorders (WRMSDs) is of central economic and social relevance. Interesting medical applications in neurorehabilitation will see tremendous growth potential in the future.

Exoskeletons are developed in the U.S., China, Korea, Japan and Europe. The initial developments were driven by military and medical uses. Large growth potential is foreseen in industrial sectors such as automotive and shipping, aerospace and many more.

The most commonly used materials are glass and carbon fibres. According to a recent scientific study on new composite technologies used for endo and exoskeletons: *"Even in the robotics field, materials of this type are beginning to be used, thanks above all to the mechanical performance they offer. Surely these new materials, which offer characteristics similar to those in humans, could favour both the rehabilitation times of patients, and also a better quality of life"* [1].

Addressing work-related musculoskeletal disorders

A recent study of the European Agency for Safety and Health at Work states: *"Musculoskeletal disorders (MSDs) remain the most common work-related health problem in the European Union (EU) and concern workers in all sectors and occupations"* [2].

This not only affects the quality of life of the workers themselves, but has a high financial impact on enterprises and society. *"Musculoskeletal disorders are impairments of bodily structures such as muscles, joints, tendons, ligaments, nerves, cartilage, bones and the localized blood circulation system"* [3].

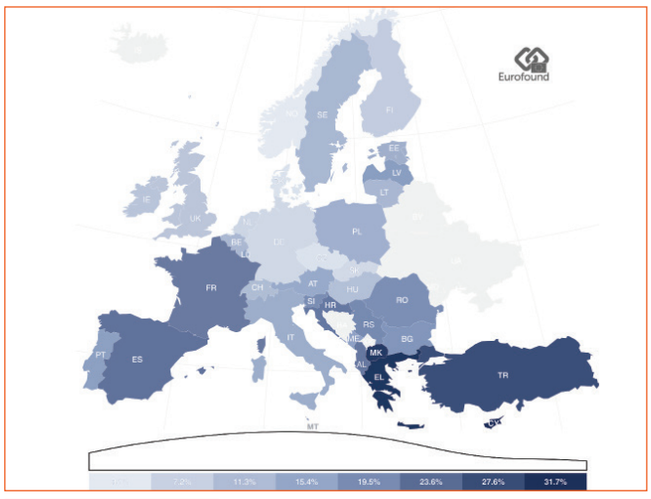

Fig. 1: Diagram showing the percentage of all employees in Europe working in tiring or painful positions (adapted from Eurofound 2019)

Focus

What are exoskeletons?

"[E]xoskeletons are wearable devices that enhance or support the strength of the user. Owing to the large number of applications and different functionalities, there is still no common definition. [However], there is [a] general agreement that exoskeletons can be defined as on-body external mechanical structures. [There] are active and passive systems. Active exoskeletons use actuators [...] to support human movements [...] [whereas passive systems] use the restoring forces of springs, dampers or other materials to support human movement.

Hybrid exoskeletons, which can be active or passive systems [...] use brain wave activities (EEG signals) or muscle activation to initiate movements [,are the future]. [T]heir use in industry is currently unlikely [...]. [The certification process is still rather difficult, since there is no uniform definition available.] Even though there are numerous studies on exoskeletons that take different aspects of usability and functionality into account, effect on the health of employees are currently poorly understood. In particular, long-term effects of exoskeletons on physiological, psychosocial and biomechanical parameters are unknown."

Source: The Impact of using exoskeletons on occupational safety and health, discussion paper of European Agency for Safety and Health at Work, 2019: http://osha.europa.eu, p. 2-8

Three out of every five workers in the EU report MSD complaints. The most common types are backache and muscular pains in the upper limbs. 60% of all workers in the EU with a work-related health problem identify MSDs as their most serious issue [4]. MSDs are the most common cause of sickness absence at work and severe disability, as well as limited capabilities up to premature incapacity at work [5].

Exoskeletons seem to be an appropriate approach to address the issue of work-related musculoskeletal disorders (WRMSDs). They can be classified into three groups: lower, upper and full-body exoskeletons and can be applied as technical, medical or personal protective devices, depending on their intended use in the workplace [6]. Growth forecasts for exoskeleton robots vary according to the respective source, but all of these statistics show remarkable growth rates. The Robotic Industries Association forecasts that the market for exoskeleton robots will reach $2.8 billion by 2023. These figures include exoskeleton robots with potential uses ranging from consumer products to military deployment. Even in aerospace, they seem to be indispensable, providing humans the only chance to move on foreign planets due to different gravitation conditions [7]. The market is expected to explode with an astounding annual growth rate of 45.2% comprising hardware and software elements [8]. Exoskeleton robots are defined as "a unique form of professional service robots, deployed in a wide range of applications, intended to mimic, augment or enhance the body's own movements". According to US market-foresight advisory firm ABI Research, the market volume for exoskeletons will reach around 300,000 items worldwide in 2028 [9]. Another recent study of Wintergreen Research on wearable exoskeleton robots predicts that the market will reach $5.2 billion by 2025 [10]. The primary applications for exoskeleton robots in today's market focus on rehabilitation services in the medical field – as the RIA report states [11]. In addition to paraplegia patients, they support patients with traumatic brain injury or those having suffered a stroke to regain part of their flexibility.

JCM discussed these exciting applications with Stephan Aderhold, vice president sales & marketing EMEA, Ekso Bionics Europe GmbH.

Ekso Bionics, a global pioneer in the manufacture of robotic exoskeletons, was founded in 2005 in collaboration with the Berkeley Robotics and Human Engineering Laboratory of the University of California, Berkeley. The US company's headquarters are located in Richmond, California. Since 2017, its European headquarters have been based in Hamburg, Germany. Ekso Bionics works with more than 300 rehabilitation clinics and hospitals in more than 30 countries around the world. EksoGT is the first exoskeleton FDA-cleared for stroke and spinal cord injury rehabilitation. It helps patients to stand and walk during rehabilitation, loaded with a powerful software that gives real-time feedback to physicians and patients. Worldwide, 15 million persons suffer from stroke attacks every year and 500,000 are victims of spinal cord injuries [12].

In the very beginning, EksoWorks, who became Berkeley Bionics in 2007, developed exoskeletons for military purposes. They were the original developers of HULC (Human Universal Load Carrier), now under military development by Lockheed Martin. HULC was designed to enable soldiers to carry heavy loads at high walking speed during a longer period [13].
Ekso, former eLegs, an intelligent bionic exoskeleton allowing wheelchair users to stand and walk, is another outstanding innovation from that company. Ekso Bionics became a public company in 2014.

Europe is an important market and the European headquarters account for almost 50% of the company's installations.
Ekso NR requires active assistance on the part of the patient and is intended for use as a gait training device to improve walking function and independence for patients with a neurological or muscular injury or illness.

Stephan Aderhold

- Vice President sales & marketing, EMEA
- With EksoBionics since 2017
- More than 12 years' experience in the healthcare sector (ophthalmology, gastroenterology, and neurorehabilitation)

JEC Composites Magazine: What growth potential do you foresee for exoskeletons in the upcoming years, particularly with regards to digitization and the new challenges associated with artificial intelligence?

Stephan Aderhold.: I think we will face essential enhancements in the near future. For therapy, our device provides many advantages. For pure mobility purposes, the current exoskeletons are not very useful or even as a wheelchair replacement. Battery runtime is still an issue although we deliver two sets of batteries, each running around four hours, making it suitable for permanent use during the day. I believe that, in the foreseeable future, patients will wear an exoskeleton much more easily, like a second skin.

What is your personal vision regarding exoskeletons for the future? If you could make a wish, what would it be?

S.A.: I wish that exoskeletons will find a broader awareness within the next years. We, as experts in different industries, have to provide targeted information and perform awareness training to explain what exoskeletons really mean to humans, how they may enrich individual lives. We have to remove people's fear of exoskeletons as robots replacing therapists or physicians and taking away their jobs. Quite the contrary, they rather make our lives easier, granting us the chance to work more effectively and efficiently and to stay healthier. Exoskeletons are still in their infancy. We will witness a lot of improvements and ways that continue to be explored within the next ten years.

With regards to the ageing population, we still might see a lot of innovation coming along. Why not imagine exoskeletons for the domestic environment, helping elderly people to lift heavy items, like a water container. There are many applications conceivable.

Fig. 2: eksoNR by EksoBionics is the next step in neurorehabilitation © EksoBionics

Maximilian Segl , principal expert composite materials & parts, Ottobock SE & Co. KGaA

Ing. Maximilian Segl joined Ottobock in 1994 after various positions in the sporting goods industry (IMS, HEAD, Kneissl, BMS, IMTech).

He was substantially involved in the development of C-Brace®, the world's only stance- and swing-phase controlled orthosis.

Fig. 3: Myo Plus arm prosthesis device: person feeding a baby calf. ©Ottobock

Another player in the market, Ottobock, based in Duderstadt, Germany, gained extensive expertise in biomechanics and orthopaedic technology with more than 100 years of experience. The company's subsidiaries in more than 57 countries employ around 7,100 people. In addition to exoskeletons for industry, they launched the second generation of the C-Brace®, the world's only stance- and swing-phase controlled orthosis. Shown in 2018 at OTWorld, the leading trade fair for orthopaedic technology, C-Brace® won the German mobility prize in 2019.

Maximilian Segl: C-Brace® can enable people whose knee extensors are partially or completely paralyzed, for example as a result of polio, to walk again. Thanks to a unique sensor technology, the orthosis controls walking movements in real time. It thus helps to achieve an almost natural gait pattern. The user can even go down stairs step-over-step. 220 units of the C-Brace complete leg orthosis were sold in 2019. The predecessor was C-Leg (1997), the world's first leg prosthesis to be controlled by microprocessors. A special coating on Ottobock's bebionic hand prosthesis, for example, allows the user to interact with touchscreens on mobile phones or tablets. 3D scanners and printers allow customized fabrication. The new generation is not only smaller and can be worn under clothing, but it is also lighter and the individual fitting has become easier as well. Myo Plus comes along with an App. The patient can control the movement pattern of the prosthesis and train to retrieve them on request. Assisted by eight electrodes, the prosthesis control system measures the movement patterns of the muscles in the forearm stump and relates them to specific hand movements and gestures [14].

Fig. 4: C-Brace © Ottobock

Focus

About Ottobock

Ottobock develops "wearable human bionics" for people with limited mobility – medical technology products in the fields of prosthetics, orthotics and human mobility (wheelchairs). The company, founded in 1919, also provides patient care products. The aim: to increase the quality of life and health economic benefits. With the Paexo exoskeleton, Ottobock transferred its expertise in biomechanics to applications for industry in 2018. Subsidiaries in 59 countries worldwide offer "Made in Germany" quality and employ more than 7,000 people. The company's international activities are coordinated from its headquarters in Duderstadt, Germany. Since 1988, Ottobock has been supporting the Paralympic Games with its technical know-how.

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Dr. Sönke Rössing,
head of Ottobock Industrials

JEC Composites Magazine: Ottobock Industrials was inaugurated in 2018. What was the main reason for creating a separate business sector?

Sönke Rössing.: It goes back to 2012, when Volkswagen AG's Group Research approached us with a challenging question: How could we, in a common effort, enhance the health and safety of our workers during the assembling process? After a short pause for reflection, we engaged together with VW in an EU research project called ORTAS that explored an orthotic-bionic assistance system to relieve the shoulder/neck complex as well as the torso and the back.

Workers at VW have to mount cable harnesses in the hatchback of a car in less than a minute. Our goal was to invent a health-conscious technology to make overhead installation easier and less harmful to health. During several years of research, we realized that this is in fact a genuine problem that various industries are facing, not only the automotive sector. This was the starting point for Ottobock to invest in this emerging market. Since then, I have been building up a team for this promising business unit. We are serious in what we are doing and we came here to stay.

What are the different application areas for industrial exoskeletons and what are their main advantages?

S.R.: With longer working lives due to demographic change and rising life expectancy, the risk to suffer from some sort of musculoskeletal disorder in the workplace is becoming more likely. Our Paexo exoskeletons are geared to support workers in heavy lifting or when performing tiring assembly activities. According to the various work-related movements and encumbrances, there are tools to protect the shoulder, neck, thumb, wrist or back. On the occasion of the upcoming Hannover Messe in April, we will launch a new product – Paexo Back. This new exoskeleton is designed to help workers lift up to 35 kg and mitigate the risk of injuries and musculoskeletal disorders. It can be deployed in many different manufacturing environments ranging from automotive and energy to aviation, aerospace, shipyards, construction and others, both for production and maintenance. The scope of application of these exoskeletons is wide. They help to reduce physical fatigue and improve ergonomics at work. Many working processes in SMEs are still not automated, but rather performed via manual intervention. Part mounting and unhooking in production are interesting fields for exoskeletons.

Fig. 5: C-Brace inside © Ottobock

Fig. 6: Paexo neck and shoulder in an assembly line © Ottobock

How much does this solution cost? Can you give us an example?

S.R.: The customer may choose between purchasing or renting the product. Usually, the customer starts with a test package for a few weeks before purchasing the item. For example, the listed price for a Paexo Shoulder is around €4,900, or €99 for leasing on a monthly basis.

What are the types of materials used?

S.R.: Textiles play a prominent role in our exoskeletons, since we are talking about wearable assistance systems that you may imagine like a backpack or protector. Textiles are also our expertise thanks to our long-standing experience with orthotics. We conduct research on mechatronic or active systems but, due to the weight factor, we very much rely on mechanical/passive systems. Here, different materials and processes play a role such as plastics, injection moulding, 3D printing, aluminium and different composite materials. We are currently trying to find an alternative to carbon for series production.

Despite its excellent properties, the price factor is an impediment. Paexo Thumb, the smallest exoskeleton as a plug-and-clip device, is manufactured by 3D printing. This passive exoskeleton relieves the interphalangeal and saddle joints of the thumb and protects the tip of the thumb during clipping, inserting or plugging tasks on the assembly line or in the paint room.

What are the major future trends for the development of exoskeletons?

S.R.: Cross-linking will become a major issue in the near future – the linkage between workpiece and worker, the human-machine interface. The active exoskeleton of the future will recognize the various challenges in production and react accordingly with the help of artificial intelligence. Our mission is to support workers in difficult working conditions. We want to contribute to enhanced working conditions in order to help them stay healthy and be able to work longer. □

More information:
https://paexo.com/?lang=en

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