

# EXOSKELETONS - ROBOTIC SUITS IMPROVING WORK IN LOGISTICS

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**Abstract:** Logistics, in the future, will be a decisive factor in the competitive struggle between organizations, economic regions and countries for value creation. The level of competence in logistics primarily determines success in this struggle. For modern companies, supply, production and distribution issues are becoming more and more relevant. It is possible to improve this process by strengthening logistic integration and coordinated interaction with external partners and between different departments within the company. Today, with the high development of technologies, it has become possible to automate not only production processes but also the movements of a person who, for one reason or another, cannot perform usual functions, in particular, to restore or replace partially or completely human limbs. This article deals with the issue of reducing logistics workers' workload. We are talking about the development of a robotic platform, namely exoskeletons, which are designed to supplement lost functions, increase human muscle strength and expand their physical capabilities, which will significantly increase the degree of worker efficiency. This article aims to optimize and facilitate workers' work by explaining the use of exoskeletons in supply and distribution logistics.

## 1 Introduction

Logistics, supply, production and distribution issues are becoming increasingly important for modern society. This process can only be improved in terms of strengthening logistics integration and coordinated interaction, both with external partners and between the various divisions within the company.

Its continuous improvement remains relevant in the conditions of rapid scientific and technical progress for the implementation of processes and digitization in logistics. Digitization in logistics aims to speed up all processes and make them more accurate and smoother. Digital data transmission, the use of new delivery methods, automation and robotization of business processes are already changing the logistics market. In addition to digitalization, the development of technical means that help workers directly in production, warehouses, dispatch or transport is also important for logistics. Industrial exoskeletons are also modern elements that are beginning to be asserted and used in the structures of industrial logistics. The exoskeleton, as a technical logistics device, is a device that can help increase human strength by supporting the outer skeleton. The exoskeleton mimics human biomechanics in order to increase an individual's effort during movement.

The use of exoskeleton robotics allows you to reduce the load during normal activities and static load, reduce fatigue and at the same time, increase efficiency without serious associated costs. Furthermore, exoskeleton robotics can be used to reduce muscle and joint tension, minimizing the risk of injury to workers who must constantly carry or hold heavy objects in inappropriate positions.

## 2 Methodology

The exoskeleton is a device that helps compensate for lost functions, strengthens human muscles, and expands the range of motion due to its outer frame and drive parts. When carrying loads through the outer frame and drive parts, an exoskeleton can also transfer the load to the leg support platform (Figure 1). Exoskeletons generally allow humans to perform movements with greater effort and protection against external forces [1].

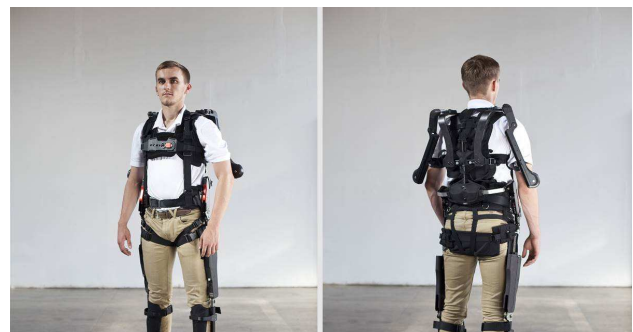


Figure 1 Modern technical device in logistics – exoskeleton  
US Bionics [2]

Industrial exoskeletons are the collective name for mechanical devices used by workers whose design reflects the structure of the limbs, joints and muscles of the operator who works with them in tandem and is used as a means of increasing capacity or as a relief to relieve fatigue and tension. It also helps with weight support, lifting assistance, load support, posture correction and body stabilization are common features of industrial exoskeletons [3].

## 2.1 Exoskeletons classification

Exoskeletons that have been developed or are in development can be classified according to the following criteria [4].

According to the energy source and the principle of operation of the drive:

- passive exoskeletons (energy independent and do not require any energy sources),
- active exoskeletons (mechanisms equipped with electric drives).

By application point (location):

- upper limb exoskeleton (to increase the strength and range of motion of the upper limbs),
- the exoskeleton of the lower limbs (facilitates walking, increases strength and range of motion),
- whole body exoskeleton (designed to increase strength and endurance; provides protection against external factors).

By price (conditional):

- low cost (affordable): 1000-10000 €,
- medium costs: 10000-50000 €,
- high costs - more than 50000 €.

According to the weight of the construction:

- light - up to 5 kg,
- medium (average) - from 5 to 30 kg,
- heavy - more than 30 kg.

The most common areas of application of this technology are:

- medicine,
- defence,
- industry.

## 2.2 Active and passive exoskeletons

According to the mode of action, exoskeletons are divided into active and passive [5].

Active exoskeletons have actuators powered by energy sources connected to the exoskeleton itself. These devices, usually equipped with electric actuators (pneumatic and hydraulic components can also be used), significantly increase the force exerted by the operator on the objects and his endurance because the effort expended to control the exoskeleton is relatively low (Figure 2).

Advantages: high speed of movement, the significant increase in force and range of motion, adjustability and the possibility of programming allow you to perform a large amount of work.

Disadvantages: dependence on external energy sources, high price, large construction and weight, dependence on climatic conditions, need for repairs and maintenance, and lack of service [6].



Figure 2 Active exoskeleton [7]

Passive exoskeletons are devices that do not need any energy source to function (Figure 3). The principle of their operation is based on the basic laws of mechanics. Passive exoskeletons distribute the load to individual parts of the body using weights and levers. By the action of a passive exoskeleton, it is possible to reduce the load on active muscles by an average of 30% [6].

Advantages: independence from external energy sources, low weight of the structure, high reliability, and low costs for equipment and maintenance.

Disadvantages: they cannot be used in the absence of residual muscle strength, inability to program, relatively low speed of movement, individual need for anatomical parameterization, and movements with limited amplitude [6].



Figure 3 Passive exoskeleton [8]

## 3 Need of exoskeletons in logistics

Full automation of logistics processes can solve the problem of trauma to employees. But this is not always possible from a technical and economic point of view. A

new high-quality tool that improves working conditions in the field of logistics is the exoskeleton. The exoskeleton allows you to work for a long time without overwork and injury. It reduces muscle tension and allows one to maintain longer working capacity during change.

Moving objects of medium weight are considered the most dangerous work. Uncomplicated, repetitive work gives the worker a false sense of security. Fatigue from monotonous activities combined with incorrect postures reduces concentration and attention, which often leads to injuries that are expensive (Figure 4) [9].

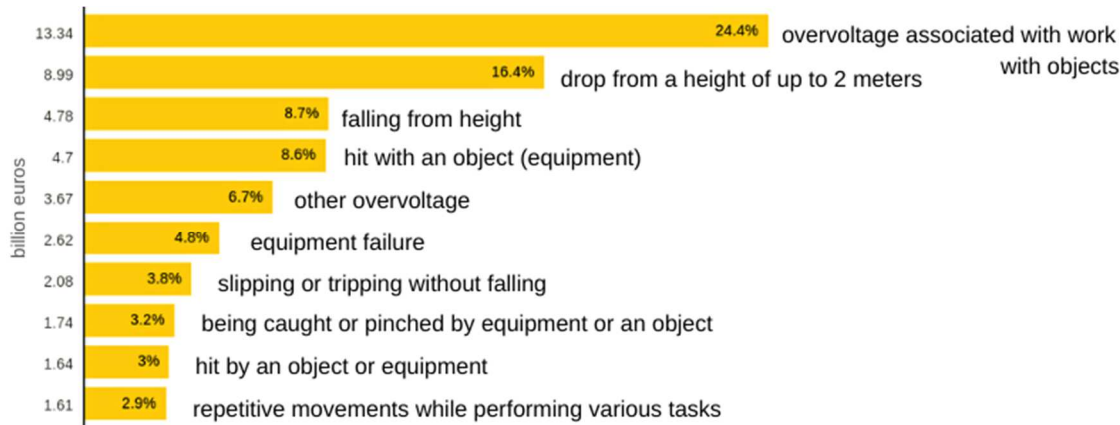


Figure 4 The relationship between the economy and accidents at work [9]

According to US sources, the compensation for the damage received is distributed as follows (Figure 5) [9]:

- 36% - injury in the lower back,
- 25% - overvoltage due to lifting, moving and throwing objects,
- 12% - knee and shoulder injuries.

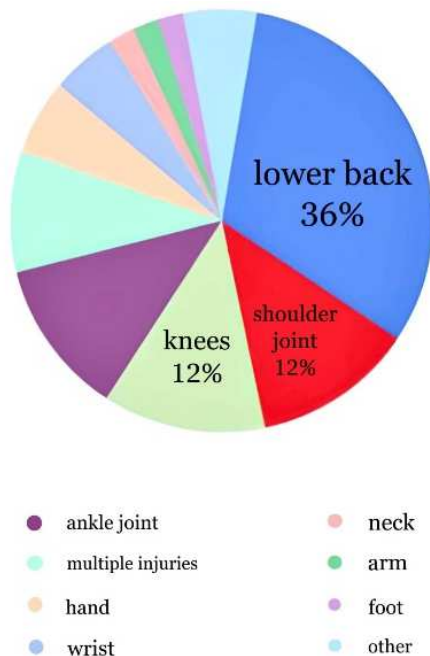


Figure 5 Diagram of the most common injuries [9]

The employee's long absence during the convalescence period leads to additional costs. Several organizations have already concluded that investing in measures to improve working conditions, including exoskeletons, is more beneficial than bearing the damage associated with temporary disability [9].

#### 4 Characteristics of SuitX exoskeletons

The popularity of American exoskeletons is due to their high efficiency, ergonomics and quality.

Strengths of SuitX exoskeletons:

- comfortable to wear throughout the working day,
- possibility of self-regulation,
- modular design,
- intelligent user movement recognition,
- ability to drive without removing the exoskeleton,
- mobility, and lack of connection to energy resources.

A large number of tests prove the effectiveness of such structures. For example, muscle tension measurements using the ShoulderX model when working with the drill showed that the load was reduced up to 6 times. The support is particularly effective in the deltoid and trapezius muscles (Figure 6) [9].

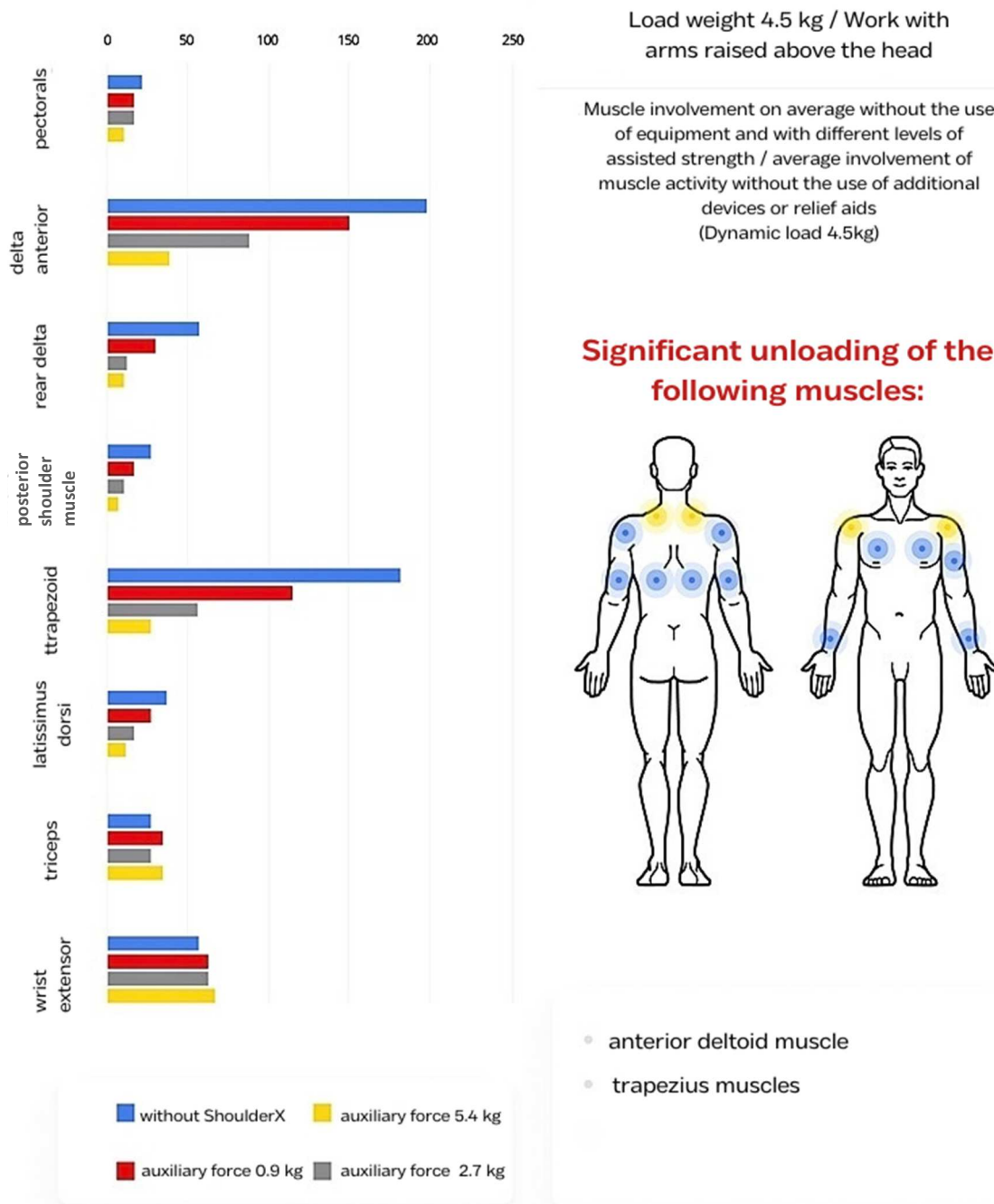


Figure 6 ShoulderX exoskeleton research [9]

Further research assessed worker fatigue during warehousing operations. As a result of the observation, the following data were recorded [9]:

- working with warehouse technology using our own resources led to feelings of fatigue after two minutes and fifteen seconds,
- when working in the ShoulderX exoskeleton, fatigue manifests itself within 15 minutes.

## 5 Advantages and disadvantages of exoskeletons

The key advantages of the exoskeleton for logistics workers are [10]:

1. Performance,
2. Increase workplace comfort with support,
3. Fewer injuries,
4. Improving the quality of work,
5. Reducing the risk of occupational diseases.

Disadvantages of the exoskeleton:

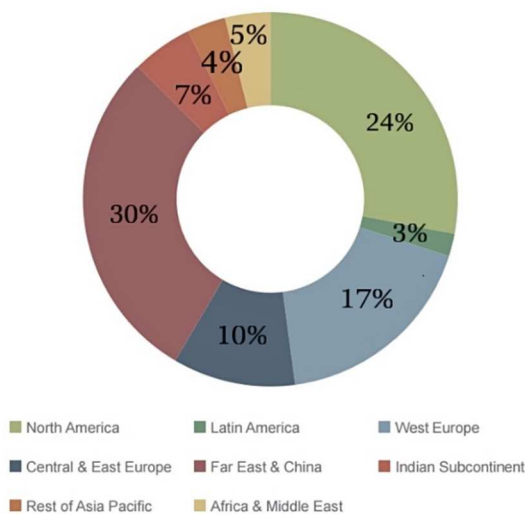
1. Costs,
2. Limited power range,
3. Material,
4. Power supply,
5. Management.

## 6 Current situation of exoskeletons on the market

As an ever-evolving market, exoskeletons today cannot yet provide many examples of practice, experience-tested practices, standards and business models. Nevertheless, the market is beginning to take shape, both in terms of expectations and challenges.

Due to a large number of producers, the Far East and China are expected to be the regions with the highest exoskeleton rental revenues (Figure 7).

The main driver of growth will be the ageing of the population. In Japan, for example, there is already a labour shortage, as the proportion of people over the age of 70 is 20% of the population. Exoskeletons are gaining popularity there and helping older people stay productive in areas requiring manual labour. Companies such as Daewoo, Guardian, Ford, and Hyundai are actively investing in this sector [11].



Source: Juniper Research

Figure 7 Regions with the largest use of exoskeletons

Nevertheless, the introduction of these types of devices provides a solution to three important business problems:

- increasing labour productivity and reducing labour intensity in manual production processes,
- reducing the number of social benefits and compensations associated with the occurrence of work accidents and occupational diseases,

- providing additional motivation for employees, which is achieved by creating more comfortable working conditions.

By 2026, the global robotic exoskeleton market will reach € 1.6 billion (Figure 8). The growth of the global market is due to the ageing of the population, technological innovations and the expansion of their application in the military industry, healthcare and industry as such [12].

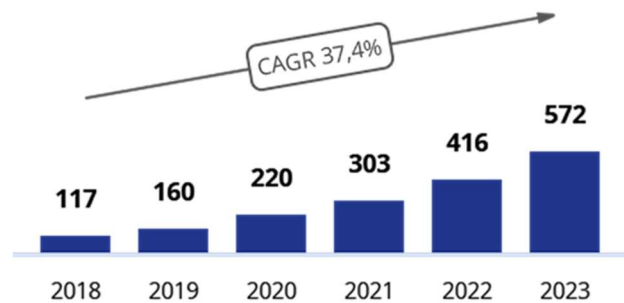


Figure 8 World exoskeleton market forecast, EUR million

## 7 Conclusions

Due to the constant change of products, the company needs to improve the system of technological preparation of production in order to ensure fast and high-quality implementation during the development of a large number of technological processes. The most modern and promising field of robotics is the creation of mobile robots, specifically exoskeletons.

In logistics and production, the physical workload of employees is often very high, which in the long run, represents a major burden on the health and productivity of workers. Workers are often tense or exceed their work capacity when moving heavy objects, which is a major problem today.

With the help of exoskeletons, it is possible to compensate for physical disadvantages and prevent posture deformities and physical deterioration of a person's condition because excess physical exertion is eliminated. This means that exoskeletons are actively used to help employees do their job safer, longer and more efficiently.

Suppose workplaces cannot be ergonomically optimized due to spatial layout or other specific conditions. In that case, the exoskeleton can help restore balance by stabilizing certain parts of workers and thus reduce the effort required to perform difficult or monotonous activities and increase efficiency and quality of work.

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## Review process

Single-blind peer review process.