University of New South Wales

Graduate School of Biomedical Engineering

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Exoskeleton Week 6 Draft Report
Assignment Title

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BIOM1010
Engineering in Medicine and Biology

Exoskeleton
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2018 Semester 2

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Draft Report

The concept of the exoskeleton was first demonstrated in the animal kingdom. Many creatures such as grasshoppers, cockroaches, crustaceans, and shelled molluscs have an exoskeleton rather than an endoskeleton for structure in their bodies. One of the first human uses for an exoskeleton was patented in 1890 by Nicholas Yagn [1]. Named the *“Apparatus for facilitating walking, running, and jumping”*, it used gas stored in a bag to facilitate certain actions. The purpose of the apparatus was to reduce the energy required by humans to walk, run and jump thus increasing endurance. The next major example of exoskeleton research and development occurred during the 1960s. General Electric collaborated with the US military in attempting to build a new kind of exoskeleton powered by hydraulics and electricity [2]. The Hardiman, as it was called, had the sole intent of increasing the strength of a human by *“a factor of 25”* for moving cargo and heavy equipment. It was abandoned in 1971 without ever being tested on a human due to technical problems.

From these initial attempts at pioneering exoskeleton technology, the concept of the exoskeleton for human use focused on improving human strength and endurance. Over time, the word ‘exoskeleton’ has become synonymous with wearable machines (that do not involve the replacement of a limb or organ) with many devices for different applications in the fields of medicine and industry *(refer to table 1)*.

Table 1: Exoskeleton Application Based on Anatomy & Physiology

Field	***Anatomical & Physiological Problems***	***Exoskeleton Application***
Industry	Deterioration of tissue from acute or repetitive actions	Prevention of deterioration by reducing stress on muscles, tendons, ligaments
	Limitation of human muscle strength	Actively augmenting lifting and holding so that the exoskeleton holds most of the weight
Medicine	Paraplegia	Exoskeleton provides an alternative to a wheelchair
	Tendon therapy post-injury	Exoskeleton helps practice degrees of movement for better recovery in tendon healing
	Stroke	Physical therapy for faster and better recovery in rewalking

In industry, exoskeletons can be used to prevent injuries in the workplace by easing stresses and strains on workers' bodies. Actions that require repetitive movements or difficult maneuvering of limbs (eg. overhead work) can be made easier by exoskeletons that support suspended limbs or offset loads while lifting [3]. In doing this, exoskeletons can increase productivity while reducing adverse long-term effects on the workers. Exoskeletons can also prevent injury from acute injury on workers' bodies by reducing the load and forces acting on the body. As a result, worker health and safety is maintained which can improve the reputation of the company and save the company from financial liability. However the technology is cutting-edge and highly specialised, quantitative data as to the outcomes in health and safety is neither reliable nor readily available.

Humans are preferred over robots in many aspects of industry particularly where judgement or creative direction is required. Exoskeletons represent a halfway point between manual work and full automation, where humans are able to exercise fine control and judgement while also being able to utilise the physical advantages of machines. This is similar to what the Hardiman was trying to achieve by helping to move cargo and heavy equipment.

In medicine, exoskeletons take an entirely different approach to improving upon the human body where exoskeletons do not focus on prevention but rather promote the standards of health for patients post-injury. One such example lie in patients with paraplegia. Paraplegia generally refers to a loss of function and/or sensation in the lower half of the body anywhere from the middle of the torso downwards. As a result, patients are entirely dependant on the wheelchair for transportation which can be unwieldy and restrictive - representing a significant shift in their lifestyle and quality of life. Exoskeletons can replace wheelchairs by mimicking the functions of the legs. Thus giving the patient access to spaces that would otherwise be restricted from wheelchair access and greatly increasing their quality of life.

For patients who have experienced trauma to the tendons, they must undergo therapy which consists of exercises that are considered vital for full recovery [5]. Exoskeletons have the potential to make tendon therapy efficient and safe. Depending on the severity of the injury, tendons may take up to 2 months to heal where the body parts involved with the tendon are immobilised to encourage matrix regeneration within the tendon. The tendon must then be exercised to avoid the tendons “sticking” to surrounding tissues during matrix regeneration. Too much exercise, however, can result in the tendon being injured again. From this, there lies the risk of patients under or over-exercising during therapy. Therefore exoskeletons which perform the required exercises for the patient with the correct intensity will allow an efficient and safe recovery.

A stroke occurs when blood is blocked from reaching an area of the brain for more than a few minutes. The lack of oxygen causes the cells in that area to die, causing impairment to whatever bodily function that those cells controlled. One of the common effects of stroke is paralysis to one side of the body, called hemiplegia, requiring extensive treatment and physical therapy to regain motor control. Exoskeletons help with the process of physical therapy by offering more control to the patient. This is especially important in gait recovery, which is one of the main goals of stroke rehabilitation [6].

The human anatomy and physiology for movement from its muscles, ligaments and tendons are susceptible to injury. The exoskeleton addresses these vulnerabilities by placing less strain on the user or guiding the user through therapy by working in tandem with the human body. This machine addresses a wide variety of current-day problems in both industry and medicine where its applications have the potential to raise the standard of life within society.

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