INTRODUCTION

Merely 20 years ago, having a spinal cord injury meant spending the rest of a lifetime in a wheelchair and with limited mobility. Half of all human spinal cord injuries (SCIs) lead to chronic paralysis with no cure. SCIs vary in many ways. Depending on the way the body is injured, it can result in incomplete, complete paralysis or tetraplegia. There are several bones and clusters of nerves that, when damaged, can produce permanent paralysis on the rest of the body.

In the past, a physician’s collection of treatments was limited and the provision of care for individuals with this disability was met with agitation. A study from the Reeve Foundation estimates that over 1.2 million Americans are living with paralysis that results from a spinal cord injury. As this number of paralyzed people increases and they age with the injury, the costs of treatments increase as well, “[e]ach year, paralysis costs the healthcare system billions of dollars. Spinal cord injuries alone cost roughly $40.5 billion annually […]” [1]. Due to these increasing costs, many disabled people are unable to afford proper healthcare and insurance that would adequately cover the conditions that are linked with paralysis [1].

Modern advances in neuroscience, biology, and engineering have drawn attention to the research of spinal cord injuries, producing high expectations for functional restoration. The skepticisms that SCIs are incurable are giving way to the newer advancements that could potentially repair disabled people’s abilities to move again. Through the use of neuroprosthetic technology on individuals with spinal cord injuries, the restoration of motor and autonomic functions is possible, allowing disabled people to regain control of many of their simple functions.

What Exactly are Neuroprosthetics?

For decades, there have been researchers and studies, looking at neuroprosthetics as ways to side step disabilities and neural deficits to improve body functions, including the ability to see, hear, help muscular/paralysis disabilities, slow Alzheimer’s. A neuroprosthetic is a device that is used to connect with input and output of data in the nervous system, it “[…] can be categorized as output neural interfaces, which convert the brain’s intentions to external actions, or as input neuro interfaces, which take information from the environment and convert it into perception […]” [3]. The device stimulates various parts of the nervous system, which included the brain, nerves, muscles, and the spinal cord, which allows for motor, sensory, and autonomic functions to be restored.

The Types of Neuroprostheses

There are several ways to use and implant neuroprosthetic devices. One way is called Electroencephalography, it uses brain signals from the scalp and interprets them as commands. By placing electrodes on the scalp, it is possible to record the electrical rhythms produced by the brain. Then a computer identifies the changes in the wavelengths and amplitudes and interprets it to detect any type of output. This output is then analyzed by the computer system and programed as a command, for instance, a command to move a robotic hand. This is a common clinical trial to study how to help people with immobility to move objects and robotic prosthetics with their brain waves because it is noninvasive. Another, more invasive use of neuroprosthetics, is by record electrodes that are implanted directly onto the brain. By having a direct implantation, the brain tissue provides a higher-resolution measurement of single neuron activations that can be read more accurately. This technique is more commonly used for severely injured people with serious spinal cord injuries or limb amputations [2].

Moreover, there are many areas of the body that neuroprostheses can help stimulate and restore. Paralysis damages more than just losing movement of the extremities, it sometimes makes a person lose control of respiration, bladder and bowel movements, and sensation. Bladder
dysfunction is a significant issue that is caused from spinal cord injury, and typical bladder management involves catheterization to empty waste. Through surgical methods and the implantation of neuroprosthetics devices on the sacral nerves, “stimuli are summated by the smooth muscle of the detrusor to produce sustained bladder pressure, and though the striated muscle of the external urethral sphincter and pelvic floor contracts during stimulation, it relaxes rapidly in the longer intervals between stimulation, thus, allowing urine to flow” [4]. The stimuli also act in the methods to control bowel movements. Through the use of these types of neuroprostheses, paralyzed patients are gaining back some control of their bodies and becoming more independent in their daily routines.

**NEUROPROSTHETICS MARKET**

As explained earlier, the lifetime costs of spinal cord injuries are detrimental. The estimated lifetime costs of spinal cord injuries are greatly attributed to the severity of the injury and age when the accident occurred. The average first-year costs vary from $340,787 to $1,044,197 from the least severe, incomplete motor functional, to the highest form of paralysis, high tetraplegia. After the first year, the costs continue to pile on because of other health issues caused by their disability and assisted living costs. Moreover, after the first year of injury, only 11.8% of people with spinal cord injury are employed and by 20 years after the injury, still only 34.9% of people are employed. The costs of living with this disability is detrimental, not only to the injured, but also to health care and medical companies, which causes economical disturbances. By using neuroprosthetics to improve the way of life for SCI patients the cost of assisted living and life care plans drop dramatically. For instance, an analysis was used to estimate the costs of bladder and bowel care with and without a neuroprosthetic implantation. It found that the costs of implementing the device was cancelled out by the savings on supplies, medications, and procedures that would have been spent without the device. Not only do neuroprosthetics enhance the quality of life, it restores independence to those who had previously lost it [5].

Moreover, the market of neuroprosthetics is greatly increasing. These new devices are the forefront of technology and, in the future, will have a huge impact on society. Currently, the global market for neuroprosthetics was valued at $4.2 million, and it is expected to grow. In 2015, spinal cord stimulation (SCS) for paralysis held the largest market share of technology segment. In addition, manufactures are constantly developing next-generation technologies to restore impaired functions, like Sacral Nerve Stimulators (SNS), which makes this technology the highest estimated technology on the global market.

To continue, the development of neuroprosthetics will greatly impact society. Neuroprostheses connect to the nervous system, which controls more than just movements of the body. Through the use of developing devices, neuroprosthetics can help restore hearing and sight. Worldwide, it is estimated that 390 million people have severe vision loss and 360 million people have disabled hearing loss. New neuroprosthetics are being developed that could partially restore these senses. By connecting to the brain, neuroprosthetics can receive the brain signals for sight or hearing and function as a bridge to restore what is not functioning properly. These new advances are expanding the use of neuroprosthetics and creating a larger impact on society [7].

**CONCLUSION**

Neuroprosthetics are currently the forefront of technology and are predicted to continue growing in value. But why stop at improving the quality of life from people who suffer from paralysis? At Keio University in Japan, they have joined hands with Cyberdyne, a company that specializes in robotic prosthetics, to create a wearable cyber suit for spinal cord injury rehabilitation. The suit, “detects nerve signals generated by the brain instructing the leg to walk, then activates the motorized limbs, aiding motion” [8]. By the use of neuroprosthetics devices and robotic prosthetics, this university is that the front line of medical technology. Although this is currently in a trial stage, it could help determine how well this type of rehabilitation improves patient’s ambulatory functions. Trials like this are what the future of neuroprosthetics looks like. These trials are leading the next-generation of modern medical technology that will greatly improve the quality of life for not only spinal cord disabled persons, but also those who have damaged sensations, vision, or hearing. Albeit many...
forms of neuroprosthetics are still in testing, improvements in the devices will lead to technology that is capable of meeting the priorities of the population of people with spinal cord injuries.

**CITING AND SOURCES**


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