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Neural and Rehabilitation Engineering: Applications, Process, and Role in the Future of Medicine

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Abstract

The rate of neuro-psychological issues has been increasing day by the day due to increasing rate of social and environmental pollution all around the world. It has been actually escalating the demand for neural and rehabilitation treatment worldwide. Neural and rehabilitation engineering is one of the key inventions of modern science which most significantly enhance the entire diagnosis, communication and treatment process in the neural and rehabilitation process. Hence, the study has been keeping its concerns on developing a superior idea about Neural and rehabilitation engineering. A number of concepts relevant to Neural and rehabilitation engineering has been discussed within the overall study. It also developed understanding on the applications and process involved with Neural and rehabilitation engineering. It helps to evaluate the role of Neural and rehabilitation engineering in future of medical filed. A large number of secondary data and formations has been gathered following inductive approach within the entire process within the study to comes forth with a suitable and effective output results. The study has been found that the application of various technological support through Neural and rehabilitation engineering enhance the treatment success and impact a positive role in upcoming future of medical science.

Index Terms

Neural, rehabilitation, engineering, medical

INTRODUCTION

Neural and rehabilitation are related with each other which can treat and provide an individual with an effective neural and rehabilitation treatment. Neural engineering is a kind of discipline which has been described majorly as an implementation of neuro-scientific and engineering methods to understand, renovate, replicate and increase the methods of neutral systems [1]. Also, neuro-engineering helps to craft solutions to the issues which are related with neurological restrictions and dysfunction. The field of neural engineering depicts over the fields of computational neuroscience, experimental neuroscience, neurology, electrical engineering and signal processing of living neural tissues to work impactfully within a patient. Whereas, rehabilitation engineering implements the innovative and periodical implementation of scientific knowledge and technology to craft and construct such devices, systems or procedures which can be able to satisfy human requirements of an individual who has disabilities [2]. Rehabilitation engineering is a type of chronological engineering which helps to craft, grow, adapt, examine, implement and provide technological issues which have been confronted by people who have disabilities. There are several types of advantages, significance of using neural engineering in future medical science and healthcare sector.

The neural and rehabilitation research intends to apply neuroscience and engineering approaches to examine central and peripheral nervous system function and to craft clinical solutions for neurological disabilities or injuries within an effective manner. Certainly, neuroplasticity describes the capability of the nervous system to provide responses to upgrade insights or stimuli which have been recognized or adapted by its structure [3]. This non-static form of recognition can play an extended role within rehabilitations from such things like stroke, TBI and even neurological disease like, MS and Parkinson's disease. There are several types of norms which have been correlated with both the terms of neurology and rehabilitation and both of the terms are connected and contribute a potential impact to the present era of medical science and neural engineering has been regulated to provide proper type of rehabilitation to those required individuals.

MATERIALS AND METHODS

This study is a clear example of biomedical which has been portrayed with the help of two different types of aspects which are as follows- neural engineering and rehabilitation engineering. In this study, the execution has been done by maintaining some important kinds of materials and methods which are closely related with the subject matter. Also, in this study, the stereotypical types of metrologies have not been maintained to keep this study distinctive from other studies which are related to biomedical or provide information related to biomedical. Some types of material and methods have been selected and used to provide intensity to the subject matter and showcase depth of the topic in the field of biomedical.

In this study, the data which has been collected to execute the subject matter is secondary by nature. The reason for

collecting secondary data is to represent this subject matter within an extensive manner which can be to clarify the concept properly. Also, while collecting the data, there are certain types of approach, method and design that can be followed which can give the study a proper execution in this situation. Among two major types of research approach, the inductive research approach has been selected and used to interpret the effectiveness of the subject matter which can provide different types of information related to biomedical.

Also, as the data which has been collected for this study is secondary by trait, for this reason, the research type is secondary. Later on, while collecting data for this study, the qualitative research design has been followed and maintained. The reason for choosing this particular design is to execute more than one subject matter at the same time and for this reason, the qualitative research design has been selected and implemented to give this study a proper execution in a certain manner. Furthermore, the data which has been collected for this study, has been gathered from such sources which have been peer reviewed and all the sources are newspaper, articles and journals which have been published after the year of 2019.

RESULTS

Theme 1: Concept of neural engineering and rehabilitation engineering in medical science

In the era of technology implementation and globalization of technology, it can be either a trend or it can be a huge inclusion or diversity within the medical sector as well. A recent surge within technological fields has stated that the gap or interface between nervous systems might be the causes that majorly develop the quality of healthy living of those individuals who suffer from neurological disorders. Neural engineers are using instrumental strategies with uninterrupted benefits and clinical translation of these extending neuro technologies in an effective manner [4]. Towards the objectives research and constrictive minded individuals within the medical sector have used medical sciences and medicines which have come together to make the process understandable within the healthcare sector and biomedical periphery.

It has been often accompanied by scientific research which has been directed at the interface among those neural systems which are living by nature and non-living elements. This field brings the teams of technician together, neuroscientist, biochemistry therapist, biologists, druggist, therapist and physicians who have been working on the neural disorders which have been raised within those individuals who have suffered with neural diseases [5]. Neural engineers know the ethics and values of heterogeneity of the colleague and work as a team and fetch several aspects to inform the development of the technology that has been designed and constructed to diagnose neural disorder within different personas.

Neural engineering has been constructed with new instruments and procedures to activate fundamental research on nervous systems and examine the disorder in case any sort of disorders can be identified within an individual. Particularly, the effectiveness of neural engineering has the potential to identify novel technologies like brain machine interface, neural prostheses and implemented devices for treating patients with cure of neurological disorders in an effective manner [6]. Additionally, system level computational modelling and constructed strategies to give major information within functions of nervous systems in both factors of health and disease. Also, with the help of current research protocols which involve deep stimulation of the brain for the treatment of motor disorders, it has been used majorly within different types of medical institutions and biomedical diagnosis centres.

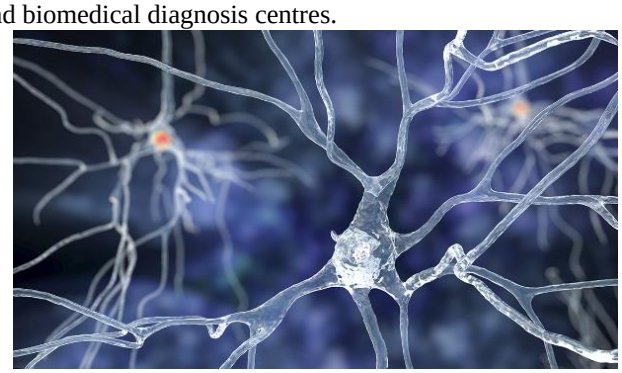

Figure 1: Neural engineering

Neuroscientists have developed novel arrays of electrodes that can help to record and stimulate a huge range of the surfaces of the brain and high resolution, data acquisition systems to wirelessly interface. These devices with the help of remote systems and genetically encoded sensors record and stimulate the brain cells by implementing lights. These instruments and other types of instruments which have been used to detect the neural disorders within the brain to understand how extended populations of neurons can effectively connect and provide information and create communicative pathways which can be identified within a dynamic way [7]. Also, in neural engineering, the computational consecutions and modelling strategies that can develop knowledge of detailed biophysical mechanisms of single neurons with the observation of actions at the population level. With these basic yet crucial types of configurations, neural engineering has been conducted within a certain manner which can give the medical science to extend its arms with new features in a certain manner.

On the other hand, rehabilitation engineering is the implementation of such engineering which consists of some ethics of medical science and biomedical jointly. The first ethic of rehabilitation engineering is to construct technologically firm solutions and devices to regulate individuals with disorders. Another ethic of rehabilitation engineering is to aid the physical and cognitive developments and its functions which have been lost because of neural diseases and neural disorders. Also, rehabilitation engineering crafts and develops devices and such systems to fetch a large range of requirements that can assist each person with sheer amount of mobility, communicative malfunction,

hearing, visionary defaults and cognition as well [8]. These instruments of rehabilitation engineering help the people and patients with assisting them in day to day actions which have been connected with employment, independent activities of the living education sector which help the people to get engaged with people who feel left out from daily activities. There are also several benefits of using rehabilitation engineering which can help the patients to live in a normal manner again.

Also, the rehabilitation engineering might include connectivity, simple and sorted observations of how an individual prefers to perform over the tasks and creating sheer type of accommodations to mitigate further injuries and discomforts from the patients. On the other side of spectrum, this process of rehabilitation engineering involves several types of sophistications about brain computational interfaces that gives the permit an immensely disabled individual to regulate computational and other types of devices by thinking about those tasks which wanted to be performed by the computers [9]. Also, the rehabilitation engineers develop standardized rehabilitation procedures to achieve the functions which have been lost for congenital disabilities, disorders or any types of injuries to retain the mobility in a certain manner.

In the ongoing process of rehabilitation engineering, it includes the design and improves the rate of innovation and technology implementation and procedures that can easily help the people to achieve physical or cognitive functions in an effective manner. In the process of rehabilitation engineering, there are rehabilitation robotics which has been used to strengthen the effectiveness of this process in biomedical science [10]. Rehabilitation robotics have been used and organized by robots as a therapy and aids in an effective manner instead of entirely regulating the assistive devices which can be able to detect any sort of disorders related to several types of neural diseases and discomforts.

In the process of rehabilitation engineering, there is another function which has been used vigorously within the healthcare sector and helps to mitigate the rate of intensity of neuro related disorder among people which is known as virtual rehabilitation. Virtual rehabilitation has been used as the stimulator of virtual reality which helps to stimulate exercises of physical and cognitive rehabilitation. Also, the virtual rehabilitation has been organized by several types of instruments of entertainment and motivating the patients to exercise and encourages the patients to stay healthy by engaging in daily activities [11]. These types of exercises and motivating sessions can be organized and performed at home and can be easily observed by the therapist along with strong internet connectivity and this process is absolutely cost effective and budget friendly from all aspects for the patients. Therefore, it can be stated that, neuro engineering and rehabilitation both are the major boon to medical science and by applying these engineering processes, the doctor and therapist can be able to diagnose and mitigate the rate of neural discomforts among patients at a rapid pace.

Theme 2: Use of neural and rehabilitation engineering in healthcare sector

Individuals with disabilities immensely suffered from sickness due to the deficiency of proper treatment a few years ago; neural and rehabilitation engineering has been working like a blessing for these people. Various technological devices and solutions have been developed by rehabilitation and neural engineering that bring a huge change in daily lives of people with disabilities [12]. In many cases, some human beings cannot recover from certain diseases; in this field, rehabilitation and neural engineering helps these people to recover from illnesses that once stop their cognitive and physical activities. There are several and different types of application of neural and rehabilitation engineering in the healthcare sector which can be immensely helpful to both the therapist and patients as well. Neural engineering devices act by interfacing with the nervous system to modulate the neural actions and most commonly implemented to understand or denote the issues which have been related to neurological dysfunctions. The deep brain stimulator is an extensive example of neural engineering which helps in several types of deeds which are related with the several neural discomforts.

The DBS has been used and targeted in the process of stimulating particular brains areas which have been examined to diagnose the symptom which have been related with different types of motor impairments like, Parkinson's disease, crucial tremor, dystonia and psychiatric discomforts like, depression, anxieties and OCDs (obsessive compulsive disorder). After extended research and all types of clinical trials and litmus tests, the DBS devices which are commercially available in the medical science and healthcare sector [13]. This technological implementation of DBS also helps to epitomize the neural engineering which has been privileged from the norm of prior biomedical and innovative biomedical engineering in an extended effective manner. DBS technology specifically the primary clinical devices which have leveraged methods which have been improved and well made for constructed cardiac pacemakers. Although implanted electrodes and relates the leads which have been crafted particularly targeted for neuro-anatomy and several devices, strategies and elements like stimulator electronics, battery and packaging have been borrowed from cardiac application.

Consequently, spinal cord stimulation has become a developed process for treating chronic pain and discomforts. Before using different stimulation techniques, it is important to do clinical trials which involve tonic, high frequency and bursting patterns which have presented particularly long term mitigation within pain which have been experienced by the patients [14]. Further, ongoing research processes within new stimulation targets, upgraded neuro-stimulators technologies and developed stimulation paradigms are enhancing the neuro-modulation market for increasing the need of pain therapy at a rapid pace.

In the present situation, the neural devices also help to reduce seizures and partially retain hearing, sights and

shipments as well. There are several types of neural engineering technologies which renovate quality of life for each and every person. The technologies have been majorly prescribed for those individuals who are deaf to retain the hearing power partially and stimulate the olfactory sensors which are related with neural abilities of an individual [15]. Also, the retinal implants can be able to help retain sights partially which have been affected by bypassing damages and also it can be restored by electric stimulator which are actually helpful to restore the hearing sights for the patients who are authentically able to hear anything.

Also, the sacral neuro-modulation therapy has been implemented to help detect the alleviated symptoms of pelvic floor disorder such as overactive bladders which is the outcome of urinary incontinence. Furthermore, the vagus nerve stimulates might mitigate the repetition of seizures in people with epilepsy who do not fully respond to the ethics of medical science. The responsive or closed circle of brain stimulation has been presented to mitigate the frequency of seizure, when it has been dramatically mitigating the entire amount of energy which has been delivered to the body of an individual. In an ultimate procedure, there are uncountable neuromuscular electrical stimulation devices and therapies to segmental restore impaired the movements of the discomforts. There are many interventions currently transitioning with the establishment of "neural engineering technologies". This engineering integration leads to a transition effect of clinical care that is able to provide clinical opportunities for nanotechnology engineers. There are several technologies that help in commercial usage to stimulate the approval of Neuropace RNS systems.

Theme 3: Process of neural and rehabilitation engineering in healthcare sector

A number of technical and strategic processes have been involved within neural and rehabilitation engineering. The entire process of performing neural and rehabilitation treatment is involved with highly critical scenarios and proper execution of the diagnosis. Though it has become essential to ensure the proper maintenance of the chronological hierarchy of the treatment process in order to provide errorless and exact treatment to the patients. The entire process of neural and rehabilitation engineering involves five respective stages which are assessment, diagnosis, intervention, monitoring and evaluation, discharge process [16]. The detailed processing performed and executed within these five stages has been analysed below.

Assessment:

The initial step which involves within this particular task is related with the entire physical, cognitive, functional capacities and the biological details of a patient, it is called assessment. The assessment steps help to gain idea and extension about the implications and diagnoses issue through proper treatment [17]. Various technological equipment

especially related to physical and cognitive tests used to proceed this particular area effectively.

Diagnosis:

The entire results which have been assumed and gained while performing the assessment process, the exact process of diagnosis of the disease, has been decided and procured within the second stages of neural and rehabilitation engineering. The goals and the objectives taken in charge in time of rehabilitation and neural treatment process of a patient through making suitable diagnosis.

Intervention:

The entire implementation of the treatment process starts within the intervention step. The resultant achievement during assessment and diagnosis process has been implicated and executed within the intervention stage. A number of modern tech variants such as AI, robotics, exoskeletons, sensory equipment used within this particular process to come forth with proper results.

Monitoring and Evaluation:

In this particular process a number of different diagnoses, assessment processes are regularly performed in order to monitor the progression of a patient's condition during availing the intervention treatment process. Necessary modification and different execution processes have been taken within the particular stage to gain a proper idea about the condition of the patient.

Discharge Planning:

The entire discharge process depends on the monitoring and evaluation steps. The next phase of recovery of the patient after completing the treatment process made within this step. The discharge operation performs after ensuring the compilation of the previous treatment process and chalk out the future plan for further rehabilitation.

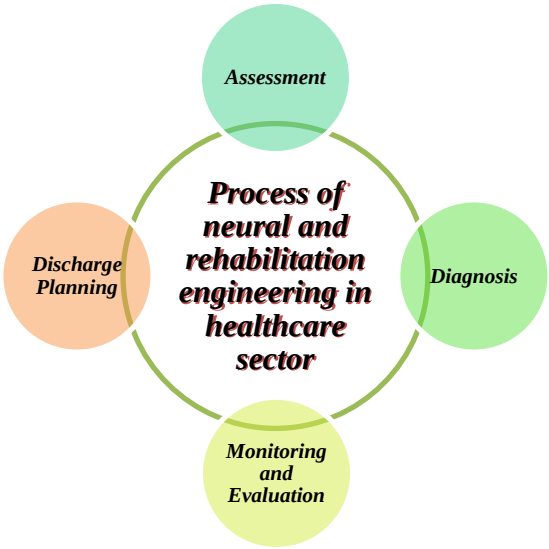

Figure 2: Process of neural and rehabilitation engineering in healthcare sector

DISCUSSION

The entire study has kept its focus on evaluating neural and rehabilitation engineering and gaining an exact idea about the applications, process of neural and rehabilitation engineering.

Neural and rehabilitation engineering is actually the entire involvement and support provided through recent days upgraded technologies in diagnosis, communication, examination, monitor, and execution of various within the entire treatment process to recover neural issues or rehabilitation needs of a patient. The study has come forth with the idea that the overall designing, developing and application criteria of technological assistance and solutions in order to resolve various issues in the area of neural and rehabilitation process. The study has showcased various technological ideas which provide the assistance to maintain a standardized, flexible and well sufficient progress in the treatment process as well has helped to improve the comfort and capacity of the diagnosis. It helps to evaluate the role of neural and rehabilitation engineering in the upcoming future of medicine.

Through using neural and rehabilitation engineering

A number of neural and psychological dysfunctions can be mitigated through the support of the technological support provided by neural and rehabilitation engineering within the treatment process. The entire diagnosis and execution process become smoother and error free through using the supports gained through neural and rehabilitation engineering. Hence, it is quite clear that the entire process and functional support provided through neural and rehabilitation engineering performs a huge role in the future of medical science. The entire quality and opportunity of innovation enhanced in future medical science and improved the success rate of neural and rehabilitation treatments as analysed within the results of the study. It mostly helps medical staff and practitioners to provide more impactful and effective medication as well as therapeutic and escalate the success to handle neurological issues of the patients and rehabilitation needs of many individuals.

The study also has portrayed the factor that the relevant diagnosis and treatment providing process of neural and rehabilitation treatment is highly complicated in nature. Any minor errors or malfunctions can cause serious issues in the neural and rehabilitation treatment process. Hence, it is essential to maintain chronological stepping within the treatment process. Neural and rehabilitation engineering offers a systematic and consecutive process which are assessment, diagnosis, intervention, monitoring and evaluation and discharge planning. It most effectively provides the support to perform the neural and rehabilitation treatment and impacts a large role on the futuristic success of medical science.

CONCLUSION

Modern world has come forth with a number of modern tech gadgets and equipment which provide the assistance to enhance the success rate of the medical service and bring on various innovative techniques in the field of medical science. Neural and rehabilitation engineering is one of the key boons of modern medical science which has most significantly enhanced the treatment process in neuro-psychological areas. The entire study has been performed in order to gain an empirical idea on neural and rehabilitation engineering as well as to evaluate the role of neural and rehabilitation engineering in the field of future medical science through analysing applications and processes involved in neural and rehabilitation engineering. A number of literature sources has been analysed within the entire study in order to gain proper idea about the associative concepts of neural and rehabilitation engineering. It most significantly helps to understand the impact of neural and rehabilitation engineering in the future of medical science.

A large number of concepts, data and information taken through secondary data collection has been involved within the. An inductive approach has been followed to gather various topic-oriented information. Data and information published onwards 2019 in authentic and peer reviewed articles and journals has been taken within the inclusion category within the study. A number of technological equipment and diagnosis techniques has been involved with the process of neural and rehabilitation engineering and helps to enhance the performance and treatments in neurological and rehabilitation traits. Various applications and processes have been analysed within the study which helps to gain a superior understanding on neural and rehabilitation engineering. The study has been found that neural and rehabilitation engineering provides a huge impact on the upcoming future of medical science.

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