INTERNATIONAL SEVEN JOURNAL OF HEALTH
ISSN: 2764-9415

Orthopedic walking aid for hemiplegia sufferers

DOI: 10.56238/isevjhv1n4-007
Receipt of originals: 25/11/2022
Publication Acceptance: 12/31/2022

Lucas de Araújo Wanderley Romeiro
MSc in Industrial Engineering; UFBA
E-mail: lucas_romeiro@hotmail.com

Bruno Soares Rabelo
Control and Automation Engineer; Unifacs
E-mail: brunorabelo@vitaesolucoes.com.br

Bruno Eurico Ferreira Guimarães Cavalcanti
Control and Automation Engineer; Unifacs
E-mail: brunocavalcanti@vitaesolucoes.com.br

ABSTRACT
The Brazilian rehabilitation market suffers from two major problems, the stagnation of product development in the area and the high cost of importing related equipment. The data regarding people with disabilities are alarming. According to the United Nations (UN), there are about 610 million people in the world with some kind of disability. In Brazil, in 2000, according to the Brazilian Institute of Geography and Statistics (IBGE), there were 24.6 million people with disabilities, about 14.5% of the population at the time (Febraban, 2006). In the United States, the cost of stroke alone increased from $40.9 billion in 1997 to $208 billion in 2000. In addition, according to data from the National Center for Health Statistics, a hospitalization for stroke in hospitals in the United States takes six days and costs US$ 4408.00 on average, with 7% of this amount referring to rehabilitation (Neves, et al., 2002).

Keywords: Orthopedic device, Hemiplegia, PCD.

1 INTRODUCTION

The Brazilian rehabilitation market suffers from two major problems, the stagnation of product development in the area and the high cost of importing related equipment.

The data regarding people with disabilities are alarming. According to the United Nations (UN), there are about 610 million people in the world with some kind of disability. In Brazil, in 2000, according to the Brazilian Institute of Geography and Statistics (IBGE), there were 24.6 million people with disabilities, about 14.5% of the population at the time (Febraban, 2006). In the United States, the cost of stroke alone increased from $40.9 billion in 1997 to $208 billion in 2000. In addition, according to data from the National Center for Health Statistics, a hospitalization for stroke in hospitals in the United States takes six days and costs US$ 4408.00 on average, with 7% of this amount referring to rehabilitation (Neves, et al., 2002).

According to research by the SARAH network of hospitals, in just six months (from 01/01/2009 to 06/30/2009) traffic accidents were responsible for 799 hospitalizations only in the hospitals of the

SARAH network in Brasília, Salvador, Belo Horizonte and São Luís. Traffic accidents are in the first category and represent the main causes of hospitalization in the Unified Health System (SUS), using approximately 30% of the budget allocated by the Ministry of Health to victims of external causes, corresponding to R$105 million per year (Ministry of Health, 2003).

Functional electrostimulation (FES) is a technique that consists of the production of contraction through electrical pulses in the motor neuron. It is depolarized, thus producing an efficient contraction. It is worth mentioning that the purpose of the device is not to eliminate muscle fatigue, since it is a natural process of the musculature, but to reduce it as much as possible.

With the creation of a process where all the necessary parameters will be automatically configured, according to the data captured by the sensors, the treatment will be simplified and the stimulus will be provided on demand, that is, the patient will only have the stimulation when he needs to perform some movement.

In addition to the problem of muscle fatigue, the device will solve the problem of getting to the offices for a patient suffering from paralysis. With the use of the system, it will be possible to carry out the treatment in their daily lives and all the data collected will be sent automatically by the wireless module present in the product, enabling the health professional to monitor the patient's condition in real time. As the condition advances, the patient will be able to use the device during a walk, for example. The professional is essential in the follow-up of the patient, as the location of the electrodes and the intensity of the stimulus will be defined from the first diagnosis.

It is quite common to confuse the terms orthoses and prostheses. Prostheses are devices that completely replace a limb lost due to amputation or congenital disability. Orthoses, unlike prostheses, help a limb with a disability or only a temporary injury. In this article, we will demonstrate the design of a robotic orthosis that uses functional electrostimulation for the treatment of patients with lower limb disabilities.

With technological advances, especially in the areas of engineering, the characterization of orthoses has changed over time. In addition to a considerable change, technological factors have caused a rapid growth in the number of alterations and creations involving orthoses. New engineering skills and the discovery of new materials, especially polymers, contributed significantly to this advance.

Among the various types of orthoses, mechanical orthoses stand out in number, but robotic orthoses will be addressed here. With the technological advancement acquired so far, many obstacles present in robotics have been overcome or minimized. The manufacture of more optimized electrical and mechanical devices has increased, thus enabling ever greater robotic advancement. This phenomenon has made it possible to create robots that have touch, vision, hearing and voice, but despite all this apparatus they are still limited machines compared to the functioning of the human body.

INTERNATIONAL SEVEN
JOURNAL OF HEALTH
ISSN: 2764-9415

2 OBJECTIVES

The detection of a device capable of detecting and controlling some variables of the patient's gait, such as intensity, speed, instantaneous acceleration and even the inclination of the motor limb. From a sensor located on the sole of the patient's foot, the system will be able to detect the pattern, intensity and speed of the step. With this data, it will be possible to identify the exact moment of the walking attempt and act to make it as safe and accurate as possible. This sensor closely resembles a button that can detect the variation of its actuation, i.e. a pressure sensor. It is necessary to control other variables to ensure accuracy and reliability in the operation of the system. Acceleration and inclination of the limb in relation to the ground are of paramount importance so that possible consequences of motor dysfunction such as imbalance and delay in movement are corrected.

The historical data will be stored on the device itself and as soon as the patient connects the device to the internet, it will be automatically sent to the database. Thus, the professional who is monitoring the case will be able to visualize, through graphs and reports, the progress or regression in the patient's condition. This will help not only the professional who will have greater ease and accuracy in diagnosing the patient, but also the disabled person who naturally has a lot of difficulty traveling to the clinics and will stop going so many times just for the professional to collect information to monitor the condition.

The data history will be read through computer software that will accompany the version of the product that will be sold only to clinics. In this same program, the health professional will not only be able to read the data generated by the device but also configure the device remotely using telemetry, that is, the patient will not have access to the configuration software, thus avoiding problems in parameterization and consequences in the treatment.

An important point to mention is the physical structure of the device, a device like this must necessarily be easy to install due to the difficulty of motor coordination of the disabled. The device is installed below the knee in the calf area, a strategically chosen location, as it is where most of the muscles responsible for the movements that have been affected are located. The installation of the product on the patient can be done with just one hand, making it easier for stroke victims, for example, to lose all or part of the movement on one side of the body. Ergonomic studies are being carried out, as comfort is one of the concerns since the patient will use the device in their daily lives.

The focus of this study is around the muscle groups responsible for human movement. Called skeletal muscles, they are controlled by the central nervous system voluntarily. Responsible not only for locomotion, but also for all the fine movements of each limb, posture and stability of the joints, therefore, a muscle dysfunction does not only cause locomotive problems, but also problems of posture and stability (Hamill & Knutzen, 2008).

INTERNATIONAL SEVEN
JOURNAL OF HEALTH
ISSN: 2764-9415

3 METHODOLOGY

Although much of the research for the treatment of paraplegia and other motor dysfunctions is focused on the use of stem cells, Neuromuscular Electrical Stimulation (NMES) is a very widespread method in the clinical environment for the treatment of people with physical disabilities. These patients usually come from sequelae acquired from a spinal cord accident, cerebrovascular or cerebrovascular accidents, traumatic brain injuries, cerebral palsy, among others.

This technique is accompanied by other sub-objectives such as muscle re-education, prevention of atrophies, temporary reduction of spasticity and reduction of contractures and edema, in addition to improving cardiorespiratory conditioning that is often impaired due to the forced sedentary lifestyle caused by the incapacity or impairment in the so-called ADLs, Activities of Daily Living. (VILLAR, 1997).

The use of Electrostimulation in a functional way requires care with a natural phenomenon called muscle fatigue. Muscle fatigue comes from overexertion. Although the cause is physiological, the good configuration and a good design of an electrical stimulator are fundamental factors for muscle exhaustion to be avoided as much as possible. Faced with this obstacle, the main points that, given due importance, characterize a good functional electrostimulation will be addressed.

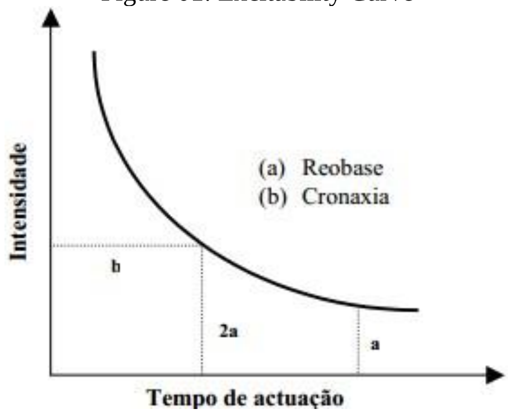
The adjustment of some parameters and characteristics of the electrical stimulus is called modulation. This modulation can be done by modifying parameters such as amplitude, frequency and waveform, up and down ramps, pulse duration (width), cycle (duty cycle), among others.

These parameters will give characteristics to the electrical stimulus, but the reaction of the muscle to this electrical stimulus, also called muscle excitability, varies from patient to patient, requiring a particular study. In view of the complexity and time required to perform tests on each patient, some statistical studies (SPSS – Statistical Package for the Social Sciences™) (RONDELLI, 2008) demonstrate mean values of these parameters, allowing only the fine-tuning to be performed in the final patient.

An electrical stimulus basically depends on its intensity and the time of exposure (Coelho & Moreira, 2001). In 1909 a French philosopher named Louis Lapicque defined the two fundamental parameters of muscle excitability, rheobase and chronaxia (LOPES, 2004). Reobase defines the value of the intensity of the smallest electrical stimulus capable of generating a muscle reaction. Chronaxis refers to the exposure time of a stimulus. Typically, the chronaxis is defined as being 2 times the rheobase, in order to obtain some response from the muscle (Coelho & Moreira, 2001).

Each nerve or muscle has different Chronoxia values, which shows that each muscle will need a specific exposure time to perform a contraction. As the value of Muscle Chronoxia is overcome, the contraction will be stronger and stronger. Figure 5 shows an Intensity x Actuation Time curve and the Reobase x Chromaxia ratio.

Figure 01: Excitability Curve



Source: (Coelho & Moreira, 2001)

For the prototyping of the device proposed in this work, visits to physical therapy rehabilitation clinics were carried out, and there parameters of the electrostimulation devices were collected, applied to the lower limbs. Data were collected and used in several patients and also tested in the technical team. To have a more precise analysis, an analog oscilloscope was used, which allowed to precisely visualize the waveform, voltage levels and frequency of the stimulus.

One of the consequences of inefficient electrical stimulation is muscle fatigue. This is a natural phenomenon, but there are studies that design maneuvers to delay this effect. The causes of this obstacle are directly linked to the demand for muscle exercise performed by a certain fiber, so an inefficient contraction leads to greater muscle effort and thus an acceleration in the fatigue process. In the case of electrical stimulation, muscle movement is not generated with only one electrical pulse, it is necessary to have series of stimuli, with a certain periodicity, consecutive and with a specific frequency of repetition. The sequence of electrical stimuli is also called the pulse train (BRAZ, 2003).

A relevant factor that should be observed very carefully is the interval between the pulse trains because the muscle needs a rest time for muscle reconditioning and/or to give the necessary time between muscle contraction and relaxation, thus generating useful movements for locomotion.

4 RESULTS AND DISCUSSION

The joints of the lower limbs of the human body have a structure like ball joints, for this reason two degrees of freedom of movement is remarkable. Despite this characteristic, the most significant movements are flexion and extension present in the entire gait movement (Hamill & Knutzen, 2008). Due to this fact, it is possible to consider only one of the two degrees of freedom present in the joints, thus simplifying the process of modeling the movement of human gait (Quevedo, 2011).

As in the study by (Quevedo, 2011), this device will have its prototype phase based on measurements collected from individuals in order to facilitate the tests to be performed. At the production stage, a statistical study will be carried out in order to evaluate the main anthropomorphic incidences and, if necessary, create different sizes according to the most expressive statistical groups.

5 CONCLUSIONS

Over the years and with the evolution of technology, human beings have been increasingly seeking to improve their lives. Accessibility is a topic that deserves a lot of attention and respect, currently we see total disregard in Brazil with the needs of people who have some special need. Technological development aimed at solutions of this type contributes not only to people who have some disability, but also generates positive results for the country, reducing the inactive portion of the population due to disability.

This study aims to show that it is possible to develop technology aimed at accessibility in a simple and inexpensive way. Demonstrate that a high-tech product can be developed within Brazil to benefit Brazilians. And that this product, in addition to being technologically viable, is economically and commercially viable and has a needy target audience desperate for new opportunities to improve their lives. The target device of this study is in the prototype stage for proof of concept,

Research is being intensified to obtain a final and stable version, to be tested, certified and produced at scale for commercialization purposes.

INTERNATIONAL SEVEN JOURNAL OF HEALTH
ISSN: 2764-9415

REFERENCES

Braz, G. P. (2003). Sistema de eletroestimulação informatizado para o tratamento da dor e para a reabilitação neuromuscular.

Coelho, T. H., & Moreira, A. L. (2001). FISIOLOGIA DAS MEMBRANAS CELULARES.

Febraban. (2006). População com deficiência no Brasil, fatos e percepções. São Paulo: Febraban - Federação Brasileira de Bancos.

Hamill, J., & Knutzen, M. K. (2008). Bases Biomecânicas do Movimento Humano (2 ed.). Manole.

Lopes, C. L. (2010). Estudo sobre a eficácia da eletroestimulação neuromuscular de média frequencia na hipotrofia muscular glútea em mulheres jovens. 2004.

Neves, A. C., Marcia, F. M., de Jesus, P. A., Clélia, F. M., Moura, R. d., Fontes, S. V., et al. (2002). Custos do Paciente com Acidente Vascular Cerebral no Setor de Emergência do Hospital São Paulo

Quevedo, A. J. (2011). Desenvolvimento de Dispositivo para Reabilitação de Membro Inferior com Deficiência Parcial.

Rondelli, R. R. (2008). Intensidade constante ou ajustável de corrente elétrica não elicita diferentes níveis de fadiga do músculo quadríceps femoral durante sessões de estimulação elétrica neuromuscular em pacientes com doença pulmonar obstrutiva crônica leve- moderada.