UNIVERSIDAD TÉCNICA DEL NORTE

FACULTAD DE INGENIERÍA EN CIENCIAS APLICADAS

CARRERA DE INGENIERÍA EN MECATRÓNICA

TRABAJO DE GRADO PREVIO A LA OBTENCIÓN DEL TITULO DE INGENIERO EN MECATRÓNICA

ARTÍCULO CIENTÍFICO

TEMA:

DESIGN OF A STRETCHER FOR PATIENT MOBILIZATION AND STANDING

AUTOR:

DIEGO FRANCISCO CARVAJAL FLORES

DIRECTOR:

Ing. DIEGO ORTIZ

Ibarra, 2016

DESIGN OF A STRETCHER FOR PATIENT MOBILIZATION AND STANDING

Diego Francisco Carvajal Flores*; Diego Luis Ortiz Morales**

UNIVERSIDAD TÉCNICA DEL NORTE

*diegofcarvajalf@hotmail.com; **dlortiz@utn.edu.ec

Abstract

Present work is born of the need to improve the quality of rehabilitation treatment for those patients that have partial or total disability, to move and change positions by themselves. As well, the need to reduce the ergonomic risk that is presented during physiotherapy, the time performing rehabilitation work with patients referred to above.

There are several possible solutions to meet the different needs that should be met by the prototype and then to analyze and select the most appropriate in each case. There is an analysis of efforts that must support the structure of the stretcher, as well as the safety factor for which is used Solidworks software; is carried out also the selection of the linear actuators that operated the different movements of the prototype.

The prototype allows you to perform the following articular movements: Bend your knees, leg lift, lifting of trunk; as well as standing and mobilization to the patient to different environments according to their needs. You can also control the height of the bed from the floor in a range of 70cm to 100cm.

Keywords

Bipedestation, stretcher, mobilization, patient, physiotherapy.

Introduction

It is important the correct use of physic therapy aimed at early mobility as by applying the recovery time of patients decreases with cerebrovascular disease of the Intensive Care Unit (ICU), so a satisfactory development is achieved; while his remains active osteo-myo-articular system, preventing deformities (Salazar & Isaac, 2015).

According to the professional perspective of teachers in the career of medical physical therapy at the Universidad Técnica del Norte, it is a need for therapists to have a stretcher for mobilization and early bipedalism to improve conditions in health care inpatient and outpatient. Using this favors the patient stretcher in changes positions and mobilization; thus achieving early mobility, which helps to improve their quality of life.

This table will help the work of health personnel is optimal without wearing the same. In turn serve to reduce ergonomic risk therapists have time for attention to the diverse needs of patients.

Today in our country, this kind of stretchers are difficult to access; one of the main causes is the high cost of acquiring them and the lack of domestic production.

This work focuses on performing an efficient design with materials found in our environment, to reduce manufacturing costs and thereby contribute to the generation of a new type of national industry.

EXISTING STRETCHERS

At the present there are different types of stretchers used for standing and early mobilization of patients; this equipment used to improve the quality of life of patients and facilitate the work of therapists, can vary in shape, size, type of drive and in turn have different functions.

It is common for standing stretchers are driven by different types of actuators, thus allowing the therapist to control the angle and speed bipedalism. They can also incorporate control of the height thereof. This type of drive makes the therapist do less physical effort and improve care for each patient; implementing these electric actuators also makes the cost of equipment increases.

It can be conjugated in the same table, standing and joint movements of the limbs of the patient; this integration generates benefits in the mobility and transfer it. In the market there is little supply of this type of stretchers and its cost is much higher than normal standing stretchers.

Bipedestation

Bipedalism is a natural position that can be taken by humans, is of great importance the practice of it by people who can not perform independently. Among the benefits of adopting the position bipedal are: the prevention of contractures and muscle-tendon contractures, prevention of osteoporosis and pathological fractures, prevention of pressure sores, reduction and control of spasticity, improved kidney and bladder function, regulation of intestinal pattern, improved cardiorespiratory function, as well as improving coordination and balance in general (Soria, 2015).

The standing devices are mechanical equipments whose primary function is to help raise a person who can not do it by itself in order to prevent loss of bone mass, improve blood circulation, improve the digestive, respiratory, kidney and urinary functions, allowing the use of the lower limbs and generate the associated psychological benefit to be at the same height of their partners (García, Saavedra, & Antonio, 2013).

Fig. 1 Standing stretcher

Source: (Respirar S.A., 2007).

In most health units in our environment equipment intended for standing patients, consist of a metal structure with wooden boards subject to it by way of table (see Fig. 1), where a therapist moors the patient and performs work place vertically by rotating the table. This type of equipment generates several drawbacks for the successful completion of therapy such as: (i) requires great physical effort from the therapist, (ii) placing the patient at intermediate angles is difficult, (iii) are not you can control the speed of verticalization according to the physiological response of the patient and (iv) does not allow the natural movement of the body to flex the joints of the legs and trunk (García, Saavedra, & Antonio, 2013).

Early mobilization of patients

Early mobility brings great benefits to the patient; according to the Society for Surgery of Bogotá - San Jose Hospital, with the implementation of early exercise has achieved 70% decrease in consumption of sedative drugs, in turn, prevents prolonged hospitalization. The application of this therapy reduces the length of stay in the intensive care unit and aims to combat the consequences of post ICU syndrome that leaves the patient's neurological and physical effects whose recovery can take up one year (Superintendencia de Industria y Comercio, 2014).

Muscle tone is the state of slight contraction of muscles and nerves dependent their central connections; as well as complex properties muscle contractility such as, elasticity, plasticity and spread ability thereof. That's why mobility is a very important part in the rehabilitation process for patients who have suffered a stroke because, through this, patients are helped to retain or regain muscle tone, to be more independent and above all to maintain a positive attitude (Salazar & Isaac, 2015).

Ergonomics in physiotherapists

The employment area of physiotherapists is very large, therefore, there are many and varied risk factors that may have an impact on their health. Cause disgruntled with the role in health units and knowledge are likely to have musculoskeletal injury when performing their work (Badia, 2011).

It should be noted that the appearance of these musculoskeletal injuries is due not only to a large number of professionals not commonly practiced ergonomic care who knows, but there are other factors such as inadequate design of workplaces, the lack of aid mechanical and equipment, and poor management of organizational work factors (distribution of breaks, schedules, job rotation ...) that influence their occurrence (Badia, 2011).

Method

System Specifications

Then the characteristics that must have the device to be designed to meet the needs that arise during the rehabilitation process is.

- To be moved easily.
- Support a maximum weight of 90 kg.
- You must have a restraint system for the patient.
- Raise the back and legs to an angle of 45°.
- Perform standing.
- Adjustable height.
- Control system with one control for the therapist.

To set the size of the sections of the stretcher is taken into account that the only critical section is about which it is the patient's femur, since this depends you can make the knee bend correctly; it is important that the extent of this section is designed according to the average height of Ecuadorians, women being the lowest average height 145 cm (Vida y Salud, 2010).

We estimate the size of the femur relative to the average height of the aforementioned person, according to the following equations.

- For women.

Height (cm) = 1,94 x Femur length (cm) + 72,84

It is obtained:

$$\text{Femur length } (cm) = 37{,}2\ cm$$

-For men.

Height (cm) = 1,88 x Femur length (cm) + 81,31

It is obtained:

$$\text{Femur length (cm)} = 33{,}9 \text{ cm}$$

kinematic diagram

Figure 2 shows the kinematic scheme of the table in which we can identify the parts that make it.

- Base (1)
- Elevation system (2)
- Standing support (3)
- Knee flexion (4) System
- Bipedalism System (5)
- Elevation system backplate (6)
- Lower limb support bars (7)
- Trunk bar support (8)

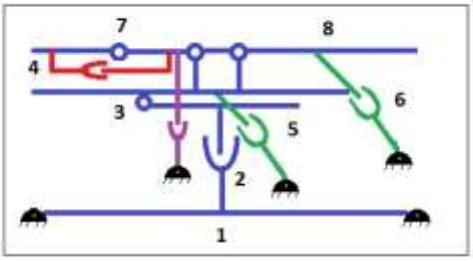

Fig. 2 Kinematic diagram.

Control system

Control of actuators

To control the input and output of the actuator stem is necessary to have a system for reverse rotation DC motor, which is generated by the movement depending on the direction in which turn.

For Reversing an inverter circuit formed by two modules relay for each motor as shown in Figure 3, thus depends on the button is pressed so that the rod entering or leaving generating desired different movement is used sections of the stretcher.

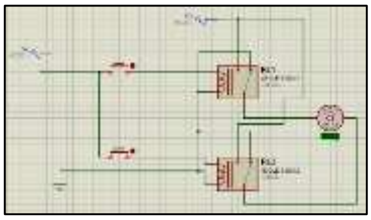

Fig. 3 Motor rotation inverter circuit DC.

For operation design a plate with relay modules, the same that are activated at 5 V and are capable of handling loads up to 250 V and 10 A. This is use. These relays are isolated using optocouplers their entry and have leds They are indicating the state in which they are.

The control system of the table will have an open-loop system for manual control of all positions and a parallel closed-loop system for controlling the height and position of the backrest.

To control the position of each mechanism is a button which controls the operation of the channel assigned to the relay module is used, allowing this or not to activate.

For each linear actuator control two buttons are used each connected to its respective channel and the output of each channel connected to one of the cables connecting the linear actuator. Thus a pushbutton causes the output of the actuator stem and the other input thereof generates.

The difference is the closed loop control is that this system has a feedback through the distance sensor which is what CENSA and sends this signal to the controller to be compared with the selected reference position using the keyboard. Thus it is achieved that the actuator reaches the required position that was predetermined in the control program.

Results

Once implemented all systems stretcher proceed to perform testing operation thereof. For this, the following tests are performed.

- Positioning of backplate.
- Positioning of the elevation system.
- Operation manual control.

Figures 4 and 5 show the positioning measurements of the different sections of the stretcher to certain predetermined angles and the error is in the same.

Table 1 Measurements positioning support 45°.

Measurements positioning support 45°		
N°	**Angle**	**Absolute error**
1	45	0
2	43	2
3	46	1
4	47	2
5	44	1
6	46	1

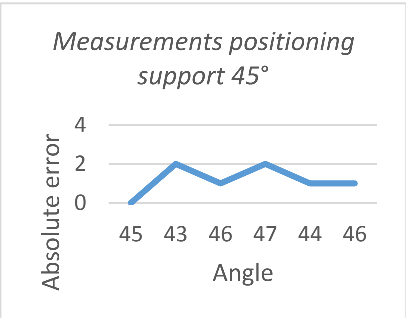

Fig. 4 Positioning measurements at 45 °

Table 2 Measurements of height positioning 80 cm.

Positioning measurements at 80 cm		
N°	**Distance**	**Absolute error**
1	81	1
2	81	1
3	78	2
4	79	1
5	81	1
6	80	0

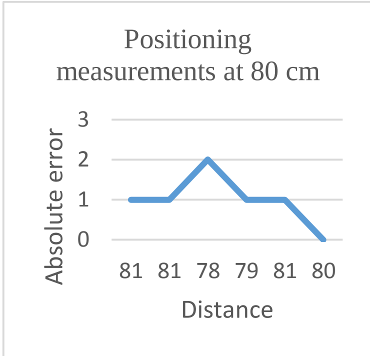

Fig. 5 Positioning measurements at 80 cm

According to the above tables the absolute error does not exceed 2 points, this makes the system efficient and feasible for the purposes required.

The absolute error does not exceed 2 points, this makes the system efficient and feasible for the purposes required.

Manual control tests are conducted using each of the buttons for the different movements and check that all functions normally work facilitating health personnel when the rehabilitation of a patient using this stretcher.

Proof of the standing of the stretcher is made having a professional physiotherapy area, and a patient suffering paralysis of his upper and lower extremities because of Guillain-Barre syndrome.

The patient is placed on the stretcher and proceeds to secure the straps and then bipedestarla, reaching the patient placed at 90 degrees from the ground. The patient feels comfortable and experience the power be in standing position without the help of anyone helping his speedy recovery.

With this the correct operation of the stretcher is shown with the type of patient for which it was designed.

Conclusions

Based on the guidelines and requirements of patients and health workers, optimal design that meets all these needs to be functional and efficient for both parties was achieved.

Kinematic design was done with what mechanisms and sections of the stretcher is correctly identified.

From the mechanical design of the structure the critical section is Identified and verified to Comply with the Relevant safety factor.

The control system was made according to the needs; having a system of open loop and closed loop system working independently.

In the construction of the structure readily available materials used in the country to improve conditions for industrialization of the stretcher.

The system passed all tests and well established can provide an efficient service health units with different movements and the possibility of being moved to different environments of the same.

Recommendations

It can be manufactured most of the aluminum structure, or other sturdy, lightweight material to reduce weight and achieve further facilitate the movement of the stretcher.

Implement other kind of automatic positioning to reduce the absolute error of 2 points.

It can improve restraint system that suits better to the different heights of patients.

Can be implemented a wireless control not to limit the employee's position with respect to health patient time to change the position of the stretcher.

List of references

Badia, E. (2011). ¿Quién cuida al fisioterapeuta? *ERGAFP*(73), 5.

García, E., Saavedra, R., & Antonio, T. (2013). Diseño de un equipo de bipedestación. *Revista INGENIERÍA UC, 20*(1), 25-33.

Ministerio del Trabajo. (10 de 08 de 2016). *Reglamento de Seguridad y Salud de los Trabajadores y Mejoramiento del Medio Ambiente de Trabajo – Decreto Ejecutivo 2393.* Obtenido de Ministerio del Trabajo : http://www.trabajo.gob.ec/seguridad-y-salud-en-el-trabajo/

Office of Communications and Public Liaison. (s.f.). *GeoSalud.* Recuperado el 14 de Diciembre de 2015, de http://www.geosalud.com/neurologia/avcrehabilitacion.htm

Respirar S.A. (2007). *Respirar*. Recuperado el 10 de Diciembre de 2015, de http://www.respirar-sa.com.ar

Salazar, L., & Isaac, C. (2015). *Beneficios de la movilidad precoz en la unidad de cuidados intensivos en pacientes con enfermedad cerebro vascular del instituto ecuatoriano de seguridad social de la ciudad de Ambato, provincia de Tungurahua.* Ambato: Universidad Técnica de Ambato-Facultad de Ciencias de la Salud-Carrera Terapia Física.

Soria, A. (2015). *VERTICALIZACIÓN DE PACIENTES CRÍTICOS DE LA UNIDAD DE DE LA*

UNIDAD DE CUIDADOS INTENSIVOS DE LA CLINICA LA MERCED EN EL PERÍODO SEPTIEMBRE – NOVIEMBRE DEL 2014. Quito: PONTIFICIA UNIVERSIDAD CATÓLICA DEL ECUADOR.

Superintendencia de Industria y Comercio. (28 de Septiembre de 2014). Movilidad temprana a pacientes de UCI garantiza calidad de vida a quienes sobreviven al estado crítico. *El Heraldo*. Obtenido de http://www.elheraldo.co/salud/movilidad-temprana-pacientes-de-uci-garantiza-calidad-de-vida-quienes-sobreviven-al-estado

Vida y Salud. (17 de Junio de 2010). *Vida y salud, las personas.* Recuperado el 30 de Noviembre de 2015, de http://blog.espol.edu.ec/wlucas/2010/06/17/estatura-promedio/