Ergomed: An assisted walking system for rehabilitation of patients with spinal cord injury.

Authors: Enrique Sanchis*, Julio Martos**, Enrique Sanchis**, José María Blasco*

*Department of Physiotherapy, University of Valencia, Spain
**Department of Electronic Engineering, University of Valencia, Spain

Abstract

We have designed, constructed and tested an automated equipment capable of supporting - partly or wholly - patients during their rehabilitation sessions. The system consists of a mechanical structure that supports a motor that drives a winch, joined by a harness in which a patient is located. The motor is controlled electronically and allows the following features: weigh the patient at the beginning of the session, set the percentage of the weight that the equipment should compensate and set the vertical scroll range allowed to the patients during the rehabilitation exercises.

The equipment has two main objectives: firstly, to provide physiotherapists the handling of patients during their transfer from the wheelchair to the exercise area, and secondly, to establish the characteristics of the exercise to be performed as well as the percentage of lift perceived by the patient and the control of both the vertical oscillations and vertical positioning.

The equipment is used along with a treadmill and constitutes a fully controlled assisted exercise system.

The system has been used in the Rehabilitation Service of the Spinal Cord Injury Unit of the “Hospital La Fe” in Valencia (Spain) during the sessions of parallel bars in spinal cord injury rehabilitation. Feedback from both physiotherapists and patients has been very positive. On one hand, the therapists have been handling the patients in a more comfortable and secure manner, due to the use of the electromechanical assistance during transfer operations. On the other hand, they have had more time to attend to other patients while performing exercises. Patients have felt safer during handling and they have conducted the exercises with more comfort and freedom. Precise control of the lift force perceived by them has facilitated their movement. Measurements of the lift force by the system have provided quantitative results concerning the evolution of their treatment.

1. Introduction

Currently rehabilitative activity is the main way to improve physical fitness in patients with SCI, both wheelchair users and also in cases of severely reduced mobility. While advances in surgery for both biological and grafting for insertion of neuro-electronic controls, provide medium to long-term research pathways leading to partially or fully recover mobility of patients with spinal cord injury, it is known that rehabilitative activity is essential to improve as far as possible, the quality of life of these patients.

There are many activities that, in this sense, are being developed in Europeans and Americans rehabilitation centers, and it was found that controlled training treadmill (treadmill), discharging the patient's legs on a portion of its own weight, considerably increases the efficiency of the rehabilitation.

Ergomed is the established name for the rehabilitation system designed, which allows the development of rehabilitation sessions to people who suffered spinal cord injuries. The patient would be suspended by a harness, which is controlled electronically so that the user receives only a fraction of their weight during exercise. It also facilitates the manipulation of these patients by the medical staff, helping both transfers and in the exercise.

2. Objectives of the rehabilitation system

The aim of this project was to apply a technique to help people with spinal cord injury (ASIA scale) to allow them to recover, within the level of the injury, the maximum physical capabilities through the process of rehabilitation.

To achieve this goal, the system should be able to facilitate the execution of the exercise and maintain very precise conditions for their realization. Thus, Ergomed should allow the patient to
work with a fraction of its weight, maintaining he remaining weight percentage. This rehabilitation system also imposed upper and lower limits of the patient trying to adopt a natural gesture in progress, and protecting them from falls due to lack of balance or strength.

2.1. Secondary objectives

In addition to the main objective, other secondary objectives have been developed:

- Providing safe transfer between the seat and the belt (treadmill), using a patient support system (crane) for transferring from the seat to the start position on the treadmill exercise.
- Providing comfort in implementing the rehabilitation exercise. To perform the exercise, patient do not need to use their arms to support themselves, so they can focus on the implementation and exercise technique.
- Improving medical personnel posture, especially in moving the patient from the chair to the treadmill, avoiding heavy physical exertion by the practitioner.
- Optimize the time spent by professionals, increasing the number of patients that can be addressed.

3. Description of the system

The equipment consists of a support system on a commercial treadmill that, by a motor and pulley system, allows compensation of the weight of the patient endure standing on the floor. It has two parts: one mechanical and one electric-electronic control (Figure 1).

3.1. Structure of the equipment

The parts of the system are:

- Metal structure: supports all mechanical, electrical and electronic equipment.
- DC Motor: generates the force to offset the weight of the patient.
- System support: transfers the force generated by the engine to the patient, which is located on your harness.
- Weight sensor (strain gauge): measures the force that the engine must compensate.
Motion sensor (optical encoder): measures the vertical movement being made by the patient.

Electric power system supplies electric power required by the motor and control electronics.

Electronic control: controls the power delivered to the motor depending on the parameters entered via the console.

Console: displays the relevant information to the operator and to facilitate the management of the entire system.

Safety switch: cuts emergency power failure or breakdown.

3.2. Technical specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient Weight Range</td>
<td>40 kg ~ 128 kg</td>
</tr>
<tr>
<td>Resolution Weight</td>
<td>0.25 kg</td>
</tr>
<tr>
<td>Vertical Movement</td>
<td>&gt;2 m</td>
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<tr>
<td>Maximum Vertical Speed</td>
<td>0.2 m/s</td>
</tr>
<tr>
<td>Weight</td>
<td>aprox. 150 kg</td>
</tr>
<tr>
<td>Dimensions (mm)</td>
<td>W 1400 x H 2643 x D 1590</td>
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<tr>
<td>Maximum onsumption</td>
<td>600 W</td>
</tr>
<tr>
<td>Electric Power</td>
<td>Monofásica 210-260 Vac</td>
</tr>
</tbody>
</table>

3.3. Procedure using

Ergomed handling is done through the console, by two buttons and a rotary knob, presenting the test data in the alphanumerical display.

To start an exercise, put the harness to the patient when he his sat in his chair or standing up.

Setting an exercise is done in four stages through the control console:

1. **Measurement of patient weight.** The weight of the patient is the most important data for this rehabilitation system. The protocol allows the patient to be lifted from his wheelchair and to make sure the heavy machine calibration. In order to avoid unnecessary risks, this protocol is completely manual. After adjusting the weight hit the OK button and the patient's weight will be recorded.
2. **Adjusting the vertical position.** Involves placing the patient in the desired vertical position, the more comfortable for scheduled exercises.
3. **Vertical adjustment limit patient.** The set value is taken as the upper limit and lower limit, of equal magnitude and opposite sign. After adjusting the vertical limit press the OK button and the upright vertical position will be recorded as zero.
4. **Start of session.** The percentage of weight compensation is adjusted manually at this time and can be modified at any time during the session. During exercise, the information displayed by the LCD screen is, on one hand, the patient upright in millimeters (left side) and, on the other hand, the weight percentage of offset (right side). If exceeding the vertical limits set, the console produces an audible warning and also stores the number of times that this occurs as an index of the capacity achieved by the patient.

4. Discussion

During the time of the use of Ergomed in the Rehabilitation Spinal Cord Injury Unit of the Hospital La Fe in Valencia (Spain), the objectives have been fully achieved.

It has confirmed the usefulness of the Ergomed as a technical support system for rehabilitation of patients with spinal cord injury for both wheelchair users and for those with limited mobility.

The assessment by health professionals on the team has been positive, standing out the safety and comfort provided in the execution of the exercises and thus their influence on the rehabilitation effectiveness.
Patients report that the precise control of the conditions of implementation of rehabilitation exercises gives them security and helps them to improve their physical condition, as they can concentrate on the execution of the movements.

5. Conclusions

- Ergomed is recognized by professionals and patients as a useful device in the rehabilitation process.
- The rehabilitation system provides security and comfort in performing exercises positively influencing the effectiveness of the rehabilitation process.
- The professionals agree that this system facilitates the optimization work resources and prevents injuries caused by intense physical efforts in sustaining patients.
- Patients welcome the improvements that Ergomed provided in their rehabilitation process.
- One of the recognized handicap equipment design is the inability of auto-calibration and therefore factors such as aging of the machine may affect the accuracy of the total weight compensated.

References:


Contact: Enrique Sanchis, enrique.sanchis-sanchez@uv.es