

Prototype of a Continuous Passive Motion device for shoulder rehabilitation

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ABSTRACT

Continuous Passive Motion - CPM - is a therapeutic method that provides fast and safe patient rehabilitation. Considering the fact that the equipment performs the movement along with the patient, who also does it but passively, this treatment procedure can immediately be applied in the postoperative care period. Although this technique makes recovery faster, as strains will be spared from ligaments, muscles and tendons, not all clinics can offer CPM therapy due to its high cost. Bearing in mind the existence of such equipment that performs the aforementioned motion, the objective of this work was the development and manufacture of a prototype device for continuous passive shoulder movement, with costs reduced to an approximate value of USD\$730.00 compared to the average price in the market which is around USD\$1510.00. This difference in values would make it affordable for a greater majority of clinics and offices to purchase them and, thus, promote the accelerated timely recovery of the limb after operation, for a larger number of patients, allowing these patients to return to their daily tasks in shorter period of time. For the execution of the prototype, specific mechanical manufacturing methods, such as turning, milling and welding of materials, were applied in order to make the equipment safe and effective, provide comfort for the patient and, above all, make the device affordable for most physiotherapy clinics. The material used for the production was stainless steel, cables, pulleys, tilting automation kit and inductive sensors.

Keywords: Continuous Passive Mobilization (CPM), shoulder rehabilitation, shoulder joint.

1 INTRODUCTION

“A problem that has given rise to the need of integrating professionals from the field of Physiotherapy and Mechanical Engineering is the development of a new device applied to post-surgical rehabilitation treatment used in joint repair. The equipment use, when associated with the rehabilitation of the shoulder joint, aims to restore the total range of the joint motion through passive arm movements, which is performed without effort or use of strength” (MASON and HOWARD, 2004).

Jensen (1999) states that passive range of motion is produced by an external force, which is performed to cause the movement of a joint, part of the body or tissue, starting from the limbs' complete immobilization towards their continuous motion.

“The concept CPM - Continuous Passive Movement was proposed by Salter in 1970, as a result of a series of empirical investigations in animals in which the biological effects on the healing and regeneration of joint tissues in rabbits were examined (O'DISCROLL and GIORI, 2000).” “Afterwards, the studies were extended to humans” (SALTER et al., 1984). “The first CPM equipment patent registration was obtained in (1978) for applications on the knee and elbow joints” (NICOLOSI and TURNER, 1978).

Shoulder rehabilitation therapy applying CPM consists of a method in which the patient remains statically seated on a chair, with the torso resting on the backrest of that chair. The patient's hand is then fitted and attached to a glove which is, in turn, attached to a cable that has the function of conducting the “up and down” movement of the CPM equipment in order to mobilize the shoulder for the time length and treatment angle predetermined by the physical therapist.

Laupattarakasem (1988) highlights that, over time, CPM method has been a crucial resource for the prevention and recovery of joint stiffness in humans, especially, for shoulder and elbow joints. Corroborating this, Mazzer (2001) points out that it can also be applied to flexion contractures, after surgical discharge, post-traumatic stiffness, caused by fractures and dislocations, and to the resolution of elbow bursitis during the healing process.

2 OBJETIVES

The aim of the present project was to apply the Mechanical Engineering expertise needed to conceive a device designed for physiotherapy focusing on post-traumatic recovery as well as post-surgical shoulder joint recovery with reduced costs when compared to the existing devices available in the market.

3 MATERIALS AND METHODS APPLIED

The purpose of the project was the development of a piece of equipment not only with easily attainable components, but also by using parts with low complexity which will not require a high cost maintenance: since anyone who has some knowledge of mechanical components can ensure the maintenance of the equipment, the project focused on its viability by providing a greater cost benefit. Some examples of the materials that did not require any manufacturing or modification were pulleys, cables, tipping automation kit, inductive sensors and casters.

4 MANUFACTURE AND ASSEMBLY

The device structure (Figure 1.) was made of stainless steel round bar 304, with $\frac{3}{4}$ diameter, and 1.2 mm(0.048 inches) to which the electric actuator and the tipping automation kit were fixed. The kit has a linear displacement carriage where a tape was attached to be fitted to an upper base supported by two pulleys and four bearings, leaving a free end meant to be coupled to the glove of predefined shape found on the patient's hand, as displayed on the schema below:

Figure 1. Continuous Passive Mobilizer - CPM.



Subsequently, the tilting automation kit was installed. The kit, which is commonly used for gate automation, is composed of a trapezoidal screw, pitch 5/8" for vertical movement and an electric motor of 0.5hp (373W), well above the minimum power required. This kit was installed parallel with the mechanical scale, with the function of performing the device "up and down motion. It was welded on the back side of the structure, with a maximum width of 1500 mm, as well as on its base: the kit was also welded on the structure plate. In order to fix the engine, 4 3/8" holes were drilled on the plate of the base to screw and fix the motor structure. After all the described procedure, cables, pulleys, inductive sensors, caster wheels, and control panel were installed.

5 RESULTS

During the operation test, which was carried out at various angles and speeds, the base structure was not displaced as there was no displacement related to the ground to be observed for any of the loads applied to the structure at any stage of the technical trial. The test consisted of repeating the operation at alternating speeds (faster and slower) for 15 minutes, with people of different body biotype and in varied positions (e.g: shoulder flexion and abduction). Nevertheless, the clinical results of the CPM application for shoulder rehabilitation treatment are still in the analysis and data-collecting phase, since the initial idea of the project was to unveil the feasibility of manufacturing the viable and inexpensive equipment.

6 CONCLUSION

The Continuous Passive Shoulder Mobilizer was designed to facilitate the physical therapists' work by reducing the physical efforts required, for helping patient recovery from injuries and surgery, in their repetitive working daily tasks. The operating tests demonstrated the viability of the project, by

exposing the prototype, which responded effectively well, to the tests performed. The results obtained leads us to believe that the equipment can be produced with the material described here at reduced costs, which achieve the aim of providing better cost-benefits to potential users.

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