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Development Of Spectra Knee Device In Rehabilitation Technology Using IoT

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Abstract: The Spectra Knee Device, specifically the kinetic Spectra, is a Continuous Passive Motion (CPM) machine designed for knee rehabilitation. A spectra knee device is a medical device used after knee surgery to improve the range of motion in the knee joint. It gently moves the knee joint through a controlled range of motion, preventing stiffness and promoting healing. CPM therapy can be helpful after surgeries such as knee replacement or ACL (anterior cruciate ligament) reconstruction, allowing patients to recover more effectively. Furthermore, knee range of motion or ROM, refers to the extent of movement that the knee joint can achieve in various directions. It is usually measured in degrees and includes movements like flexion (bending) and extension (straightening) of the knee. A normal range of motion in the knee joint allows for activities like walking, running, climbing stairs and sitting comfortably. Besides that, with rehabilitation equipment such as 'spectra knee for moving train using IoT, users can do exercises and therapy in addition to that users can also see their improvement data that has been saved every time they exercise using the equipment.

Keywords: CPM Knee Machine, Spectra Knee, Goniometer, Internet of Things (IoT), Exercise, Range of Motion (ROM)

INTRODUCTION

The Spectra Knee device is a significant advancement in rehabilitation technology, specifically aimed at aiding recovery for individuals with knee injuries or after surgeries. An assistance to the healing process following joint surgery is a continuous passive motion machine. In order to help with stiffness reduction,

circulation improvement, and the avoidance of scar tissue formation, it is meant to gently move the joint through a prescribed range of motion. Once knee, hip, and shoulder surgery, continuous passive motion machines are frequently utilized. Different continuous passive motion machine types exist, each tailored to a particular joint. These represent the primary kinds; however, due to patient-specific needs and surgical technique, there may be variances within each group. Continuous passive motion machines with different characteristics and capacities may be produced different manufacturers. The knee's rehabilitation is the project's main focus.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

The Spectra Knee device highlights its role in enhancing rehabilitation for patients recovering from knee injuries or surgeries. Continuous Passive Motion (CPM) therapy uses machines to move a joint passively i.e., without the patient exerting any effort. A motorised device moves the joint repetitively to a set of number of degrees and movement speed, determined by the physiotherapist. CPM machines are most commonly applied to the knee, but there are versions for other joints such as the hip, shoulder and elbow (Yetman 2021). CPM is most commonly used after joint surgery to promote the recovery of normal joint range of motion and thus, to prevent joint stiffness complications. It is frequently recommended after knee joint replacement or knee cartilage repair surgery. Uses of the CPM are also reported in paediatrics orthopedic surgeries or injuries for maintaining hip and knee range of motion. CPM was introduced in the early post-operative period and was combined with physiotherapy for maximum results (Chloe 2023). The device was well tolerated, without interfering with open wounds, nursing care or external fixation devices. CPM is also recommended for prophylaxis against thrombosis after total knee replacement, with some support from a small number of studies for its use (Pereiralow 2015). Joint stiffness after surgery or injury is reported to progress through four stages: bleeding, edema, granulation tissue, and fibrosis.

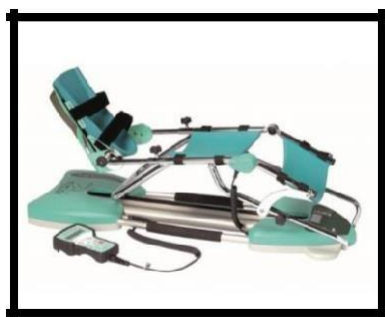


Figure 1. CPM Knee Machine

When applied during the first two stages, CPM can ensure the maintenance of normal periarticular soft tissue compliance and prevent the development of stiffness by helping pump blood and edema fluid away from the joint and periarticular tissues. (Papagelopoulos 1997) In other words, CPM prevents the initial or delayed accumulation of periarticular interstitial fluids. The duration of each session and the total period of CPM application remain controversial (Ritter 1987).

Degenerative joint disease, commonly referred to as osteoarthritis (OA) of the

knee, is usually caused by gradual loss of articular cartilage due to wear and stress. Seniors are most likely to experience it. Primary and secondary osteoarthritis are the two categories of the condition. Articular degeneration in primary osteoarthritis has no discernible underlying cause. Either aberrant articular cartilage, as in rheumatoid arthritis (RA), or an aberrant concentration of force across the joint, as in post-traumatic reasons, can result in secondary osteoarthritis.



Figure 2. Osteoarthritis Injury

A linear actuator is a mechanical device that converts electrical energy into linear motion or forward-backward motion along a linear path. The main function of a linear actuator is to move or shift an object linearly (Phil 2016). For example, by raising, lowering, pushing, or pulling a load. Linear actuators have many types, namely electric linear actuators, mechanical linear actuators, pneumatic linear actuators and piezoelectric linear actuators. Each type is used according to the purpose of the product. As for this spectra knee device, it uses an electric linear actuator. Where it can push and pull the load on the user's leg with the appropriate weight on the linear actuator.



Figure 3. Linear Actuator

L298N is a motor driver used to control the direction and speed of a DC motor. For general knowledge, L298N motor driver whose function can change a signal obtained from a microcontroller. For example, the ESP used in this project to be the appropriate electric current according to the motor. Among the important components found in this motor driver are the motor driver IC, regulator IC, control pin and power supply. If one of these components has a problem, it will have an impact on the motor driver in doing its job in controlling the circuit of the project system.



Figure 4. L298N Motor Driver

DC gear motor (DC gear motor) is a DC motor equipped with a gear or gearbox. The main function of the gear on this motor is to change the speed and torque output of the motor according to the needs of the application. This dc gear motor has two basic components which are the stator and the rotor. Each of these components plays an important role so that the electric current that passes through it runs smoothly. This DC gear motor has many types of voltage. For this spectra knee device, it uses only 12 volts where it is compatible with the device. If there is a voltage current that exceeds the corresponding voltage it will reject the current again. When this happens, the machine cannot work. This is because there is a short in the project circuit due to high current.



Figure 5. DC Geared Motor

METHODS

The use of the spectra knee device is quite different compared to the CPM machine and other spectra machines. This is because it does not have a remote or a place to control the physical outside of the machine (Golgouneh 2016). Users need to control it by using apps or software that have been connected to the machine. Based on figure 6, it displays an online control that can be used on the user's phone device. This will make it easier for users to use it. Users need to ensure that the phone device and the machine are always connected to the same Wi-Fi or internet data.

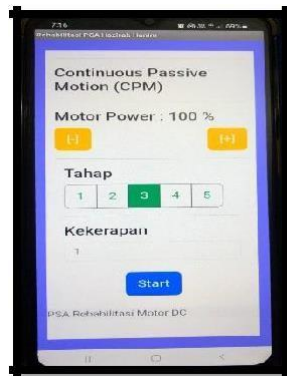


Figure 6 Software apps for spectra knee device

In addition, when the user has been able to enter the apps, the user will be able to see on the screen the motor power, level and frequency. The user only needs to control it according to the appropriate exercise reference that has been set by the physiotherapist.

Furthermore, the meaning of level 1, level 2, level 3, level 4, level 5 is the angular distance that has been measured using a goniometer (Monito 2023). Before users use these apps in more depth, users will first be given a usage guide and an introduction to each movement button. This is to make it easier for users to use this spectra knee device. Knee flexion and extension range of motion (ROM) is necessary for functional and sport specific activities. Regaining full functional range of motion (ROM) through treatment is essential because of the potential consequences that might arise from losing knee flexion or extension (Cynthia 1997). Sustained power applied for ten to forty-five minutes at a time has been shown to improve knee range of motion. When joint constraints are long-standing and may not react to intermittent effort to restore range of motion, sustained force is very beneficial (Ngoc-Bich Le 2013).



Figure 7 Knee extension to zero degree using a mobilization belt, hydraulic and towel

Based on figure 8, it shows the knee spectra design that has been made in SketchUp. This design is made in accordance with the characteristics of precision in the aspect of rehabilitation. The angle used for extension movement is 0

degrees. While for the flexion angle up to 130 degrees. This angle was taken by measuring using a goniometer. This design is also quite different compared to other spectra knee devices because it is specially designed to make it easier for users to use it anywhere as long as it is in a place that has a power supply. This is because this device is light and easy to carry by the user.

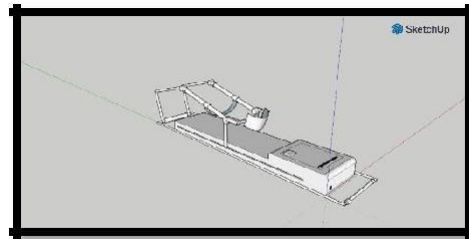


Figure 8. Design spectra knee device from the front angle

RESULT AND DISCUSSION

Based on the results shown in figure 9, it shows the exercise data that the patient did to achieve the rate of the recovery process. This exercise needs to be done every day consistently so that the recovery process happens quickly. Each patient needs to reach the knee angle target that has been set by the physiotherapist. This is because every angle reached becomes a measurement marker for the patient. Each angle will be an indicator of whether the patient is able to sit, stand and squat. The meaning of level 1, level 2, level 3, level 4 and level 5 in the graph is the knee angle measured based on the goniometer. This data has been obtained and referral results from physiotherapists [Yetman 2021].

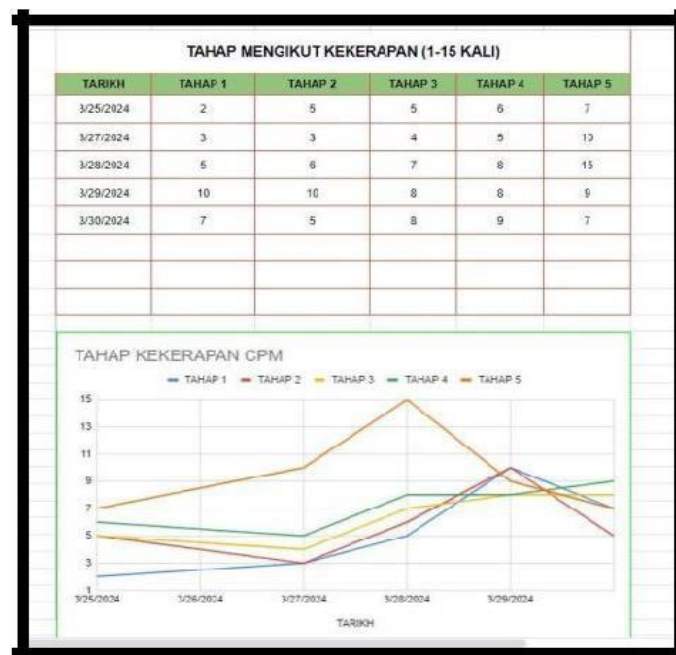


FIGURE 9. Summary of Pain Management

CONCLUSIONS

CPM knee machine and spectra knee are popular machines used to exercise for patients with knee problems. The existing CPM knee machine or spectra knee machine is very limited to use and the machine is very heavy. Therefore, with the presence of this spectra knee device, it can help the user a lot in using it easily and also has no problem carrying the device because it is light. Furthermore, this device can store user data, where each time the data is used it will be saved automatically. It makes it easier for users to see improvement over time

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