



The Development of Spectra Knee CPM Moving Train Walk Review

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Abstract: Total Knee Arthroplasty (TKA) is common for the management of arthritis but can cause knee stiffness. Knee stiffness can make the patient fail to move the joint and difficult to perform certain activities. The patient may take months of physical therapy to recuperation that motion. Continuous Passive Motion (CPM) is a postoperative treatment technique that is intended to help recuperation after joint surgery. Continuous Passive Motion machines are a rehabilitation device that use in post-surgery. Knee CPM machines passively and repeatedly moves the joint through a specified range of motion (ROM) to gently flex and extend the knee joint. This machine is capable to eliminate the problem of stiffness, reduce pain and swelling, reduce scar tissue formation, increase range of motion and flexibility of knee.

Keywords: Total Knee Arthroplasty (TKA), Knee Osteoarthritis (OA), Range of Motion (ROM), Continuous Passive Motion (CPM)

1. Introduction

A study of C. Saturveithan had find out in Malaysia, there are 9.3% of adult Malaysians have knee pain and more than half of them have clinical evidence of OA. The prevalence ranges from 1.1% to 5.6% in the various ethnic groups in Malaysia. TKA is one of the most common procedures performed during hospital stay, and according to the national registries, there is a continuously increasing number of operations performed worldwide each year. [1]

A study of S. W. O. Driscoll declares that TKA is common for the management of arthritis but can cause knee stiffness. [2] Knee stiffness can make it difficult to perform certain activities including standing up from a seated position. [3] Continuous Passive Motion (CPM) is a postoperative treatment technique that is intended to help recuperation after joint surgery. Passive range of motion (ROM) implies that the joint is moved without the patient's muscles being utilized. Continuous passive motion (CPM) is an option to providing regular movement to the knee using a machine. The Continuous Passive Motion (CPM) machine is a rehabilitation device that has been produced for patients to

use in post-surgery.

A CPM machines can assist the duty of physiotherapist and accomplish such routine physical movements without the assistance of physiotherapist. Therefore, a CPM machine is actually widely used for knee rehabilitation because it can increase recovery of knee range of motion (ROM) and able to make the joint back to normal motion as soon as possible. [4]

Besides that, a knee CPM machines passively and repeatedly moves the joint through a specified range of motion (ROM) to gently flex and extend the knee joint. It will be used after surgery to allow the knee joint to slowly bend. By placing the knee in this machine soon after surgery, it will generate increased blood flow and nutrition to the injured site while moving the limb or joint. This machine is capable to eliminate the problem of stiffness, reduce pain and swelling, reduce scar tissue formation, increase range of motion and flexibility of knee. [5]

2. Literature Review

2.1. Knee Joint

The knee joint is the largest joint in the body and also most

important joints in the human body. It was the strongest joint to take our weight and must lock into position so we can stand upright. It allows the lower leg to move relative to the thigh while supporting the body's weight. [6]

Movements at the knee joint are essential to many everyday activities, including walking, running, sitting and standing. [3] The knee joint is also known as the tibiofemoral joint, is a synovial hinge joint formed between three bones: the femur, tibia, and patella. Two rounded, convex processes (known as condyles) on the distal end of the femur meet two rounded, concave condyles at the proximal end of the tibia.



Figure 1. Knee Joint.

2.2. Total Knee Arthroplasty

According to The Bay of Plenty District Health Board, Total Knee Arthroplasty (TKA) is an operation where removing natural knee and replaced by an artificial one. The reasons for replacing a knee are varied but the most common is degeneration due to osteoarthritis. The operation is designed to reduce pain and increase mobility. The replacement parts will consist of a metal cap placed on the end of the femur and a plastic cap placed on the top of the shin bone. Sometimes, a plastic insert is used to replace the kneecap. [7]

Besides that, a proper rehabilitation after a TKA is essential to the recovery. Physical therapist will help patient regain much of knee range of motion through Rehabilitation therapy. So the physiotherapists will tailor range-of-motion exercises, progressive muscle-strengthening exercises, body awareness and balance training, and activity-specific training to patient specific needs. [7]

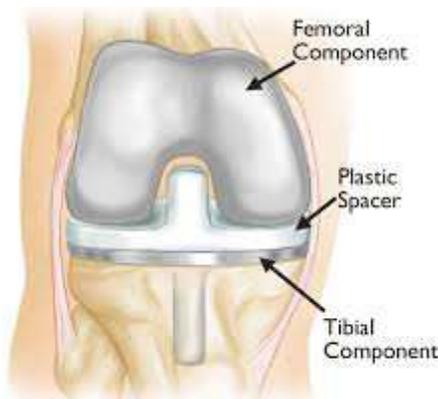


Figure 2. Total Knee Arthroplasty.

2.3. Range Of Motion (Rom)

Range of motion (ROM) is a term commonly used to refer to the movement of a joint from full flexion to full extension. It is also known as joint movement, full flexion and full extension. According to Q. Mourcou, exercise physiologist and physiotherapist's measure range of motion in a joint with an instrument called a goniometer that measures joint range of motion in degrees from the starting position. Extension is a physical position that decreases the angle between the bones of the limb at a joint. [8] It occurs when muscles contract and bones move the joint into a bent position. The opposite movement, flexion, bends the joint so that the joint angle shortens.

Injuries to the soft tissues surrounding a joint often reduce range of motion due to swelling and tissue damage. Based on A. Tendon and I. Active, regaining range of motion in a joint is one of the first phases of injury rehabilitation, and physiotherapists often prescribe specific ROM exercises for each joint. [9]

Loss of knee flexion has been shown to bring altered gait pattern affecting the ankle and hip, limited functional squatting, and difficulty negotiating stairs and sitting. The loss of knee extension can cause altered gait pattern influencing the ankle and hip, powerlessness to achieve the closed packed position of the knee, and difficulty running and jumping. [10]

According to D. Renata and D. Ireneusz, there are three primary types of exercises specific to range of motion which is passive, active-assistive and active ROM. The passive ROM is typically practiced on a joint that is inactive. The physiotherapists may use this exercise on a client who is paralyzed or unable to mobilize a specific joint. This type of exercise can help prevent stiffness from occurring. During this exercise the patient does not perform any movement, while the physiotherapist stretch the patient's soft tissues.

Active-assistive range of motion exercises is more dynamic, intended for the client to perform movement around the joint, with some manual assistance from the physiotherapists or from a strap or band. These exercises can often feel painful, and the muscles can feel weak. Increasing range of motion with these exercises ought to be a steady headway.

Active range of motion exercises are highly independent, performed solely by the client. The physical therapist's role might be basically to give verbal prompts. [11]

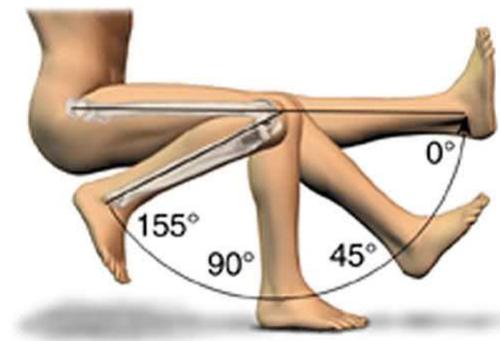


Figure 3. Knee Range of Motion.

2.4. Continuous Passive Motion

According to by Shawn W. O'Driscoll (2000), he said that Continuous Passive Motion (CPM) is a technique used for rehabilitation of joints following injury to or surgery on articular tissues, including cartilage, tendons, and ligaments. CPM involves movement of a joint without active muscle contraction, and is accomplished with motorized devices that move the affected joint through a prescribed arc of motion for an extended period of time.

It is generally well accepted that CPM of the joint creates increased synovial fluid movement, intermittent compression, and soft tissue tension, and experimental animal studies suggest that CPM can promote clearing of blood in the joint, stimulate production of new cartilage, and decrease cartilage vascularity. CPM involves movement of a joint without active muscle contraction, and is accomplished with motorized devices that move the affected joint through a prescribed arc of motion for an extended period of time. [2]

2.5. Existing Knee CPM Machine

In numerous medical centres as right on time as in the principal hours, days, instantly after introductory surgery; CPM machines are becoming widely used for rehabilitation. They are utilized not just to help in the knee-joint rehabilitation process, but also in the other joint rehabilitation example like the hip-joint, the elbow-joint, the shoulder-joint, the wrist, the fingers and the feet joints or the stimulation of the muscles around the mouth and the lower jaw. Clearly, the structure of the CPM machines differs depending on use. Currently on the market we have a large number of different solutions and their structures may vary from each other depending on the manufacturer providing the devices. [12]

Kinetec Spectra Knee CPM



Figure 4. Kinetec Spectra Knee CPM.

Knee CPM is used to increasing blood-flow and reducing swelling through natural motions. This machine was difficult to carry and it's also costly. So every times the patients need to attend themselves to the hospitals for the treatment. Besides that, this devices need AC power supply to operating.

3. Methodology

3.1. Brushed Dc Gear Motor

The locomotion of the Knee CPM Device was achieved by

utilizing DC geared motor. The model was use is ZYTD520, which bought from ZHENGK. The rated voltage is 12V, with the flexible speed at 100 RPM.



Figure 5. DC Geared Motor.

These types of motor were uses to control the upward and downward movement of the knee. Besides that, the application of screw jack was also apply in this project, which it used as mechanical lifting. The DC geared motor was use to rotate the ball screw, and a nut will moves along the ball screw. When the motor move forward, the screw will rotate in clockwise, and the nut will moving forward from the motor, at this situation the nut is moving the knee upward. So when the motor move reverse, the nut will moving reverse from the motor, which the nut will pull the knee downward. The lifting nut of screw jack is used to decrease friction.

3.2. Arduino Uno

Arduino is an open-source electronics prototyping platform based on flexible, easy-to use hardware and software. In addition to Arduino's simplicity, it is also inexpensive, cross-platform and open source.

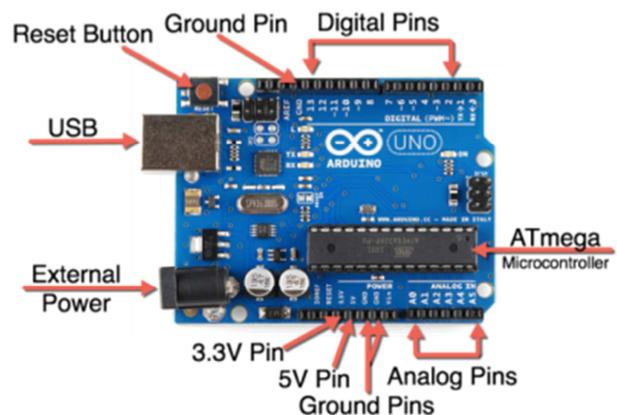


Figure 6. Arduino UNO.

Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by

controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language and the Arduino Development Environment (Arduino IDE). Besides, Arduino UNO was used to control the speed, count of the movement and also the level of the device.

The Arduino UNO is read the setting from the user, and produces the output as the settings from the user. The user can select the speed that required, how many count needed and also the level of the angle, these are the settings that the user can decided themselves. Once the settings was done, the PIC will read the setting and produced the output depends on the requirement of the user.

3.3. Software

The Arduino project provides the Arduino integrated development environment (IDE), which is a cross-platform application written in the programming language Java. It originated from the IDE for the languages Processing and Wiring. It provides simple one-click mechanism to compile and upload programs to an Arduino board.

Arduino IDE is chosen as the programming software for this project because of its open source and easy to understand. A full program was written in Arduino IDE and then the program will be debugged and compile by Arduino IDE. Besides that, an Arduino USB 2.0 cable was used to load the hexadecimal coding into the Arduino board by a loader program in the board's firmware.

3.4. Data Collection

The method that uses for data collection was distributed questionnaire. There were two test that uses for this project which is usability test and clinical test. For the usability test, data was collect in the area Electrical Engineering Department, at Polytechnic Sultan Salahuddin Abdul Aziz Shah. 30 subjects were takes for the usability test, those are the students from the Electrical Engineering Department. First, the Spectra Knee CPM Moving Train Walk was used on each of the subject, difference levels was test on the subject. After the testing done, questionnaire was distributed to all the subjects.

For the Clinical test, Total Knee Arthroplasty (TKA) patient or patient knee post-surgery rehabilitation was taken as the subject of the clinical testing. The data will collect in the hospital.

4. Result

The result is develop a knee CPM machine that recovery ROM for TKA patient post-operative rehabilitation. After that, this machine was usually used by the therapist in hospital to assist their therapy session with the patient. Therefore, these machines will conjunction with manual range of motion exercises and apply in rehabilitation therapy for knee arthroplasty post-operative patient. In addition, it will also capable to reduce pain and discomfort for the patient. The example of result was refer table 1. [13]

Table 1. Wound Healing.

Would Healing (5 th postoperative Day)	Yes	(N)	No	(N)
A (Standard CPM)	93.5%	43	6.5%	3
B (Early Flexion CPM)	98%	47	2%	1
C (No CPM)	92.3%	48	7.7%	4
P	.44			

Source: Lisa A. Bennett (2005)

5. Conclusions

CPM devices was one of the effective rehabilitation equipment. After knee joint surgery, due to the severe pain and immobility of the patient, the tissue around the knee become harder and knee stiffness will occur. The CPM devices was proved by research. Likewise, numerous issues such as scar tissue swelling, bleeding, and fibrosis will likewise be created. Therefore, a CPM machine is a device that which is being used for patient recovery and retrieving moving abilities of the knee. In addition, it also reduces tissue swelling after this surgery. Common CPM machines are bulky and expensive. Furthermore, the patient may needs someone to assist on using these devices. Due to these problems, the patients need to attend to hospital sometimes to do the therapy. Thus, a lighter and portable CPM machine with a simple use interface is designed in this study.

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