MUSCLE PAIN THERAPY

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DECLARATION

I hereby declare that the work in this thesis is my own work carried out of one year Final Year Project for the award of Bachelor Of Electronic Engineering Technology (Medical Electronic) With Honours. Under the guidance of my supervisor Ida Maria binti Yusuf.

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ABSTRACT

Muscle Pain Therapy is one of rehabilitation device that help sport player to improve soft tissue healing and give relief for both acute and chronic muscle pain. It is focus on knee and ankle section for process healing. The purpose of this study is to develop muscle therapy that is portable for tissue recovery of sport player. The important part of this device will help to reduce the cost of patient care and reduce the time for a player to recover from sports injuries. This project gives patient new alternative and can be used at home. It will ease the athletes or sports players to carry out treatment when injured. This project is developed by using the red and near infra-red light over tissue injuries. Data collected by two ways that is in technically test and evaluation test. Analysis of the effectiveness of laser therapy for muscle pain and sport injury was made by testing the equipment on patient. By using Laser Therapy, healing time for muscle injury were reduced and recovery process not cumbersome as it is portable.

ABSTRAK

Alat Terapi Otot ini adalah salah satu alat pemulihan yang membantu ahli sukan untuk melakukan proses penyembuhan tisu lembut dan memberikan bantuan untuk keradangan otot yang sakit dan kronik. Ia memberi tumpuan kepada bahagian lutut dan buku lali untuk melakukan proses terapi otot. Tujuan kajian ini adalah untuk menyediakan terapi otot yang mudah alih untuk terapi pemulihan tisu ahli sukan. Bahagian penting peranti ini akan membantu mengurangkan kos penjagaan pesakit dan mengurangkan masa untuk ahli sukan pulih dari kecederaan yang di alami. Projek ini memberikan alternatif baru kepada pesakit dan boleh digunakan di rumah. Ia akan memudahkan para atlet atau ahli sukan untuk menjalankan rawatan apabila cedera. Projek ini dihasilkan menggunakan cahaya merah dan cahaya infra-merah melalui kecederaan tisu. Data yang dikumpul oleh dua cara yang diuji secara teknikal dan ujian penilaian. Analisis keberkesanan terapi otot ini digunakan untuk rawatan kesakitan otot dan kecederaan oleh ahli sukan dibuat dengan menguji peralatan pada pesakit. Oleh itu, dengan menggunakan terapi otot ini, masa penyembuhan untuk kecederaan otot telah dikurangkan dan proses pemulihan tidak rumit serta alat ini adalah alat yang mudah alih.

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INTRODUCTION

1.1 Background of The Study

Muscle Pain Therapy is the application of red and near infra-red light over tissue injuries to improve soft tissue healing and give relief for both acute and chronic muscle pain. The intensity of Muscle Pain Therapy and LED's is not high like a surgical laser. There is no side effect, so Muscle Pain Therapy is completely painless. Red LED and near infrared therapy is used to increase the speed, quality and strength of tissue repair, resolve inflammation and give pain relief and is usually done by our physiotherapist. MPT has undergone over 1000 published laboratory studies and is already proven in over 100 successful randomised double blind controlled clinical trials (RCT's). These trials include osteoarthritis and other sports injuries as well as back and neck pain.

Then, from the another research that make spectra taken from the wrist flexor muscles in the forearm and muscles in the calf of the leg demonstrate that most of the photons at wavelengths between 630–800 nm travel approximately 23 cm through the skin surface (light input) and muscle, exiting at the photon detector [1]. Red Light also known as Photonic Therapy is a safe, natural, non-invasive way to promote healing and control pain. This therapy has been proven to help animals as well as people. Our product emits a specialized 660nm red light which can be applied directly to the skin. This technology has been studied for over 40 years and produces fast relief and healing with minimal, if any side effects.

Low energy photon irradiation by light in the far red to near infrared spectral range (630–1000 nm) using low energy lasers or light emitting diode arrays has been found to modulate various biological processes in cell culture and animal models [1]. Red and near-infrared light can penetrate tissue because they are not blocked by blood or water as much as other wavelengths. This wavelength is used in medical settings for burn treatment, wound healing, joint and muscle pain, sports injuries, etc. Moreover, the machines made available to medical professionals are considered to be cost prohibitive for the average person. Over the past several years, new technology allowed improved battery efficiency, increased voltages, and more light output to be packaged into a small affordable device.

The lower of wavelength, the more superficial the healing. A 600-700nm wavelength heals the surface wounds. Then, the lower wavelengths heal more superficial type wounds. It is estimated that the depth this light reaches is about 1cm. This treatment would be beneficial for things like is diabetic ulcers or bed sores and surgical incision sights[2]. Photonic therapy works because the body's tissue can absorb this type of light at a cellular level, converting it to cellular energy (known as ATP). Many studies have shown that this energy accelerates activity in the mitochondria (the part of the cell that generates protein, collagen, and healing materials) as well as improving blood flow in the area being treated, speeding healing and minimizing pain.

1.2 Problem Statement

From what we can see, sports players or athletes often occur internal injuries like torn tissue, so they take a long time for recovery the injury to normal condition. Therefore, they took a long time to rest from representing the team to the organized competition. In addition, majority of the therapy device that are available in the market are not portable or less mobility. This will cause the patient to attend the therapy session in hospital. With portable muscle pain therapy, patients are able to do the exercise session at their house.

Then, costs for medical rehabilitation is quite high when patients need to use a recovery method to use the tools that are expensive when experiencing severe pain in the tissue. Patient difficult to afford medical patients who have done.

1.3 Objective

The main objectives of this project are:

i. To develop laser therapy for tissue recover of sport player injury
ii. To ease the patient and physiotherapist to carry and uses the devices.
iii. To analyze the effectiveness of muscle pain therapy for sport injury

1.4 Scope of Project

Sport player with range from 20 years to 30 years, both male and female is the scope for this project.

1.5 Significant of The Project

This project will help to reduce the cost of patient care and reduce the time for a player to recover from sports injuries. Besides, it can make it easier for the athletes or sports players to carry out treatment when injured.

CHAPTER 2

LITERATURE REVIEW

2.1 Muscle Pain Therapy

2.1.1 Low-Level Laser Therapy

Light in its various forms has been used for healing from the time of the ancient Egyptian and Greek civilizations. The negative effects of the absence of light on the human body are well documented (e.g., seasonal affective disorder, also called SAD lack of vitamin D production rickets, etc.). Therapy using LASER, an acronym for "light amplification by stimulated emission of radiation," is based on the beneficial use of light for healing. Recent advances in laser therapy devices and more research into the appropriate dosages have dramatically improved the results of this therapy.

Another randomized placebo controlled trial treating activated Achilles tendonitis in seven patients demonstrated that LLLT suppresses inflammation, measured by reduction in the inflammatory marker. Further, LLLT improved clinical indices of pressure pain and sing hop function in these patients. Laser light energy is highly absorbed by skin and subcutaneous tissue.

Therefore, penetration is key to therapeutic result. Longer wavelengths and higher power output result in deeper penetration and higher dosage to the tissue. Larger laser therapeutic dosage levels produce improved clinical outcomes as illustrated in the case and interventional studies cited above[3]. Low Level Laser Therapy (LLLT) is the use of red and near-infrared monochromatic light to enhance the body's natural healing processes. The light source is placed in contact with the skin, allowing the light energy (photons) to penetrate tissue where it interacts to increase circulation and help restore normal cellular function. LLLT does not break the skin as do surgical lasers. The Food and Drug Administration (FDA) approved LLLT (with this approval came a new classification of therapeutic devices, referred to as NHN), known by many other names, such as cold laser, non-thermal laser, soft laser, bio stimulation laser, low-intensity laser, and low-power laser therapy, as an effective method for temporary pain relief. The LLLT is the type of laser most commonly used in your doctor of chiropractic's office.

The low energy laser pulses can be adjusted to penetrate more deeply and more aggressively into the skin tissue, depending on the condition and goals of treatment. The light energy, which can be delivered by either a large device that emits multiple laser panels at once or a hand held device for smaller targeted areas, will pass through the skin layers to reach the cells and tissue causing the pain and inflammation. The laser device is held against the skin over the area being treated. The light energy is absorbed and converted to biochemical energy, which stimulates the cells. That activates the natural healing process of the cells, which reduces pain, increases blood flow, and stimulates repair of the tissue. That show in (figure 2.1) the higher the wavelength the deeper it heals. A beam that measures 700-1000nm is not as easily absorbed by the epidermis (skin)[2].

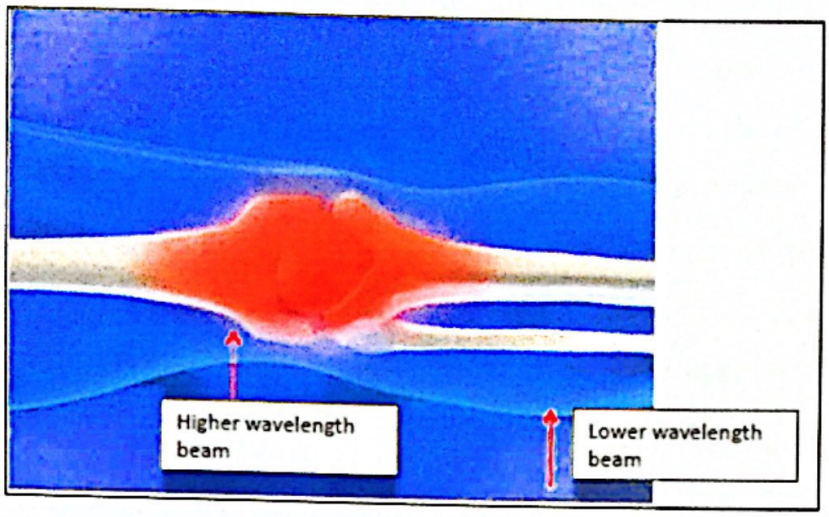


Figure 2.1: wavelength of light penetrate at knee muscle

2.1.2 Pain Relief

LLLT has various protocols for different conditions. The treatment provider must know the exact location, cause, degree, and frequency of back pain in order to select the appropriate protocol for optimum performance. Understanding the exact condition causing the back pain also can guide how many treatments will be needed for effectiveness, and how frequent the treatment sessions should be. LLLT is used to help heal wounds and to treat many types of musculoskeletal injuries and disorders. As research continues, the use of lasers is expanding. LLLT is used to treat both acute and chronic pain. At the cellular level, photobiomodulation can modulate fibroblast proliferation, attachment and synthesis of collagen and procollagen, promote angiogenesis, and stimulate macrophages and lymphocytes by improving energy metabolism within the mitochondria.[4]

Before recommending LLLT treatment, a provider must diagnose the condition to confirm that the issue is pain from a neuromusculoskeletal condition caused by aging, injury, or genetics and that there is no disqualifying condition or contraindication for laser use. For example, if the back has visible lesions on the skin, it must first be confirmed that they are not cancerous before

the patient can undergo laser therapy. Pregnant women also are not good candidates for LLLT the effects on unborn children are unknown. Although the FDA says cold laser treatment is safe and has no known side effects (the LLLT involves low energy beams and very low absorption rates that can't harm the skin tissue because of complete absence of heat), the depth of tissue penetration indicates that it could affect certain conditions, such as cancer, pregnancy, and thyroid issues. Also, lasers should not be used near the eyes.

Then, rat model of ischemic wounds, a decrease in wound size and acceleration of wound closure has been demonstrated in rats treated with 880nm NIR Led light. Four human studies using NIR Led light therapy have demonstrated greater amounts of epithelialization for wound closure and accelerated healing of skin grafts. That to determine if NIR Led light treatment can improve impaired healing, we used a murine model of diabetic healing, which is characterized by a delayed re-epithelialization 22 Polyvinyl acetal (PVA) sponges were implanted subcutaneously in the dorsum of genetically diabetic mice. The mice were subsequently treated with 670nm NIR Led light, and wounds were harvested for RNA analysis.[4]

2.1.3 Targeting Inflammation

For inflammation, laser therapy causes the smaller arteries and lymph vessels of the body to increase in size, which is called vasodilation. Vasodilation allows inflammation, swelling, and edema to be cleared away from injury sites more effectively. Vasodilation in lymph nodes promotes lymphatic drainage, which also aids in the healing process. Bruises are often resolved faster due to this effect.

LLLT usually requires more than one treatment for optimal pain relief. The benefits of LLLT appear to be cumulative it may take several treatments for the results to become evident. From the reports, that it can take anywhere from

eight to 30 sessions for the treatment to be fully effective, and some patients find it necessary to undergo treatment two to four times per week. The total number of treatments needed depends on the condition being treated, the severity of the condition, and each patient's individual response. Overtreatment isn't possible, and an added benefit is that there is no recovery time so patients simply can read or relax during the typical half hour treatment.

2.1.4 Sports Injuries

Close up of a foot with bandage. Laser therapy has been adopted as an essential pain management tool by athletic trainers in most major league sports franchises in the United States, as well as by many Olympic teams. Trainers claim that elite athletes make comebacks faster after being injured when LLLT is part of the treatment plan. It has five major league pitchers for example, use lasers as part of a normal warm up routine and many athletes use them as part of rehabilitation.

Indirect injury and direct injury can occur in two ways first the actual injury can occur some distance from the impact site. For example, falling on an outstretched hand can result in a dislocated shoulder. Second the injury does not result from physical contact with an object or person, but from internal forces built up by the actions of the performer, such as may be caused by over-stretching, poor technique, fatigue and lack of fitness. Ligament sprains and muscle strains and tears are examples of these injuries.[5]

Injury occurs suddenly to previously normal tissue. The principle in this instance is that the force exerted at the time of injury on the tissue (ie. muscle, tendon, ligament, and bone) exceeds the strength of that tissue damaging it. Forces commonly involved in acute injury are muscular contraction (eg. Muscle

or tendon tears), twisting injury to joints (ankle sprains, knee ligament injury) and direct contusion (impact from an object or opponent).[5]

Doctors of chiropractic also use lasers to treat the weekend athlete with common sports injuries such as plantar fasciitis, hamstring pulls, and various muscular strains. The laser can help any level of athlete heal faster and with a more positive outcome.

2.1.5 Inflammation

Inflammation (from Latin inflammatio) is part of the complex biological response of body tissues to harmful stimuli, such as pathogens, damaged cells, or irritants and is a protective response involving immune cells, blood vessels, and molecular mediators. The function of inflammation is to eliminate the initial cause of cell injury, clear out necrotic cells and tissues damaged from the original insult and the inflammatory process, and to initiate tissue repair.

Inflammatory cells are important components of the successful repair of injured muscle. The early use of NSAIDs, which inhibit the function of macrophages and neutrophils, leads to a slower muscle regeneration than in untreated animals (Almekinders & Gilbert 1986). The impaired recovery in the muscles of treated animals was attributed to both the slow removal of cellular debris and the decrease in synthesis and release of soluble factors important for the activation of regenerative processes by macrophages. Because the early response of inflammatory cells to muscle injury is a determining factor in directing muscle repair, there is an argument for not using anti-inflammatory drugs during this period.[6]

Inflammation is a vital part of the body's immune response. It is the body's attempt to heal itself after an injury defend itself against foreign invaders, such as viruses, bacteria and repair damaged tissue. Without inflammation, wounds would fester and infections could become deadly. Inflammation can also be problematic, though, and it plays a role in some chronic diseases. Inflammation is often characterized by redness, swelling, warmth and sometimes pain and some immobility. When it stubs that been toe, for example, biochemical processes release proteins called cytokines as "emergency signals" that bring in the body's immune cells, hormones and nutrients to fix the problem, according to Dr. Scott Walker, a family practice physician at Gunnison Valley Hospital in Utah. It is useful to differentiate inflammation and infection as there are many pathological situations where inflammation is not driven by microbial invasion for example atherosclerosis, type three hypersensitivity, trauma and ischaemia. There are also pathological situations where microbial invasion does not result in classic inflammatory response for example, parasitosis, eosinophilia.

2.1.6 Healing

Healing (literally meaning to make whole) is the process of the restoration of health from an unbalanced, diseased or damaged organism. Healing is a completely natural process. It is thought to be a flow of beneficial energy between the healer and the recipient that deals with the "dis-ease" at its deepest level. Then, the physical damage or disease suffered by an organism healing involves the repair of living tissue, organs and the biological system as a whole and resumption of normal functioning. It is the process by which the cells in the body regenerate and repair to reduce the size of a damaged or necrotic area and replace it with new living tissue. The replacement can happen in two ways by regeneration in which the necrotic cells are replaced by new cells that form similar tissue as was originally there or by repair in which injured tissue is replaced with scar tissue. Most organs will heal using a mixture of both mechanisms.

Then, it presence of specific proteins in the tissue is required to produce a viable cellular structure and to play a tissue specific role accounting for the properties of a system. Thus, skeletal muscle can be approached from a molecular viewpoint, particularly the contractile proteins which account for the mechanical function and performance. Several families of proteins present a high degree of molecular variability, due to the existence of multiple isoforms. Some of the proteins accounting for the contractile and metabolic properties exist as adult mature and developmental immature isoforms.[6]

It is also referred to in the context of the grieving process. In psychiatry and psychology, healing is the process by which neuroses and psychoses are resolved to the degree that the client is able to lead a normal or fulfilling existence without being overwhelmed by psychopathological phenomena. This process may involve psychotherapy, pharmaceutical treatment or alternative approaches such as traditional spiritual healing.

2.2 Muscle Injury

2.2.1 Muscle and Ligament Injuries

A muscle strain or ligamentous sprain can result from strenuous activity and lead to a tear of the affected structure. This is characterized by pain, tenderness and functional limitations. First degree strains are involve stretching muscle or tendon fibers without tearing. Second degree strains are involving partial tearing of the muscle tendon unit. Third degree levels result in complete severance of the tissues involved.

A severe muscle strain or contusion injury causes secondary damage to the blood vessels resulting in the formation of a hematoma, which may be described as a pooling of blood in the interstitial tissues. This can develop into

a firm mass in the subcutaneous area. The associated edema and inflammation can delay the recovery of cellular function by limiting arterial perfusion of the area.

Muscle injuries are very common in persons who participate in sports. In addition to the inconvenience and discomfort associated with such injuries, they also have a significant economic impact if the work related costs are considered. The spectrum of these injuries is wide and includes contusion, laceration, delayed-onset muscle soreness, and muscle strain. Contusion is caused by a direct blow to the muscle and is treated with a three phase treatment program that involving. First a short period of immobilization with the muscle in a lengthened position. Second passive and active range of motion exercises. Lastly, is strengthening[6]. Muscle strain is by far the most common muscle injury suffered in passive tension on the hamstring muscles and potentially injure them[6].

2.3 Knee Injuries

2.3.1 Characteristic of Ligament

Ligaments of the knee is a mobile and complex joint that allows, to perform many movements and motions. The ligaments of the knee such as, the anterior cruciate ligament (ACL), the posterior cruciate ligament (PCL), the lateral and medial cruciate ligaments (LCL, MCL) help control knee motions by connecting bones and by offering the knee joint stability. They also help the knee to absorb shock during motion and activity. There are two ligaments on the sides of the knees, the LCL and MCL, and two crossed ligaments in the center of the knee, the ACL and PCL. The ACL crosses from the back of the femur to in front of the tibia, and can be injured by twisting the knee or by changing directions too quickly (playing basketball, downhill skiing).

The PCL prevents the tibia bone from sliding too far backwards, and is often injured when an object forcefully strikes the shin backwards (football, car accidents). The MCL connects the femur to the tibia along the inside of the knee joint. It is often injured by a side blow or injury to the knee (playing football). The LCL connects the femur to the fibula, and is often injured as a result of a direct blow to the inside of the knee joint (soccer, karate). After sustaining a ligament injury, the knee can feel unstable and cause disruptions in your everyday activities, such as walking[7]. Besides, knee joint is held in place by four large ligaments. These are thick, strong bands which run within or just outside the joint capsule. Together with the capsule, the ligaments prevent the bones moving in the wrong directions or dislocating. The thigh muscles also help to hold the knee joint in place[8].

2.3.2 Diagnostic Guide

Patients suffering from knee pain are commonly seen in clinical practice. Pain may be caused by local structures within around the knee or may be referred from other sources (such as the lower back or hip joint). Sudden onset knee pain often occurs in athletes involved in fast moving change of direction sports, kicking sports, contact sports and those sports which involve twisting movements or rapid acceleration and deceleration (such as football, soccer, basketball, netball and alpine skiing). These acute injuries often involve tearing of cartilage tissue or ligaments within the region (figure 2.2). One of the most common causes of sudden onset pain in the knee is a Medial Meniscal Tear often presenting as pain at the inner aspect of the knee.

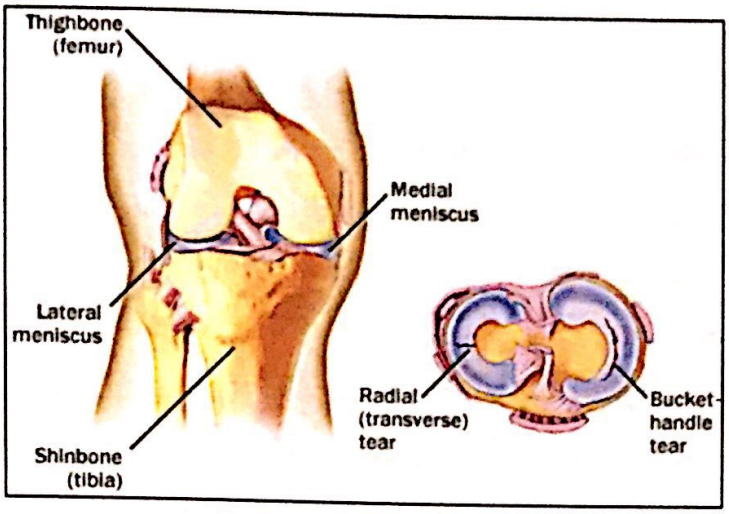


Figure 2.2: Anatomy of a Medial Meniscus Tear

Gradual onset knee pain often occurs in those patients involved in sports or activities that involve high running loads, repetitive squatting, lunging, jumping, twisting, kneeling or repetitive kicking. One of the most common causes of gradual onset pain located at the front of the knee is Patellofemoral Pain Syndrome. Patients with gradual onset pain located at the inner or outer aspect of the knee are often due to either a Medial Meniscal Tear or Lateral Meniscal Tear (figure 2.2). In older patients with gradual onset knee pain, the most likely cause of symptoms is degenerative changes in the knee or patellofemoral joint, such as Knee Osteoarthritis. There are numerous other causes of knee pain, some of which present suddenly due to a specific incident, others which develop gradually over time. Below are some of the more common causes of knee pain with a brief description of each condition to aid diagnosis. Conditions have been organised according to sudden or gradual onset and common or less common conditions for ease of use (figure 2.2).

2.3.3 Type of Sudden Onset Knee Pain

a) Medial Meniscus. Damage to cartilage located at the inner aspect of the knee joint (medial meniscus) usually due to excessive weight bearing or twisting forces. Pain is usually located at the inner aspect of the knee and often increases on firmly touching a specific area of the inner knee joint line. Swelling and a clicking, catching or locking sensation may also be present. Symptoms are usually exacerbated with excessive weight bearing, deep squatting and twisting activities.

b) Lateral Meniscal Tear. Damage to cartilage located at the outer aspect of the knee joint (lateral meniscus) usually due to excessive weight bearing or twisting forces. Pain is usually located at the outer aspect of the knee and often increases on firmly touching a specific area of the outer knee joint line. Swelling and a clicking, catching or locking sensation may also be present. Symptoms are usually exacerbated with weight-bearing, deep squatting and twisting activities.

c) MCL Tear. Tearing of the medial collateral ligament of the knee (MCL) typically following a valgus force or twisting movement and often associated with a snap or tearing sensation at the time of injury (figure 2.3). Associated with pain on firmly touching the MCL and often swelling. Occasionally associated with knee instability or giving way of the knee.

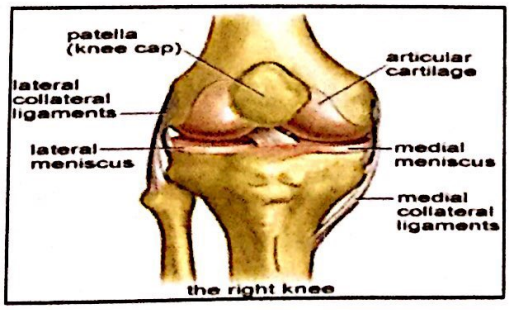


Figure 2.3: Anatomy of a MCL Tear

d) Meniscal tears (figure 2.4). The common history is of a twisting injury on a knee that is bearing the body weight, while the foot is stable on the ground. A history of contact with another player is unusual. However, with the ageing process, degenerative tears of the meniscus may also occur and these might not give such a clear history of sporting trauma but rather may be associated with minor twisting injuries. The knee may often have a diffuse swelling, which develops overnight (effusion). Meniscal tears may sometimes be a part of a complex knee injury where other knee ligaments are also injured.[9]

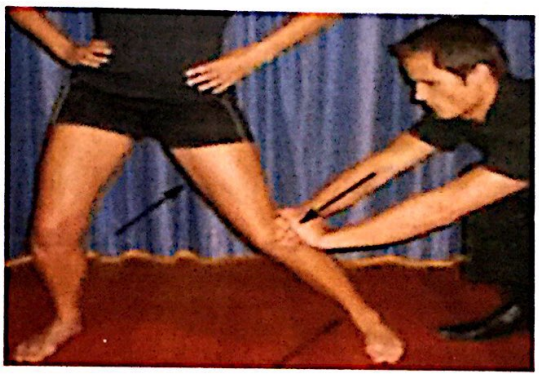


Figure 2.4: Valgus force (often involved in a MCL tear)

e) ACL Tear. Tearing of the anterior cruciate ligament of the knee (ACL) typically following landing from a jump, sudden deceleration, or due to a hyperextension, sideways or twisting force (figure 2.5). Often associated with a 'snap', 'pop' or 'tearing' sensation or feeling of 'something going out and then going back' at the time of injury. Usually associated with severe knee pain at the time of injury, significant swelling within a few hours of injury and a feeling of knee instability or giving way of the knee during certain movements.

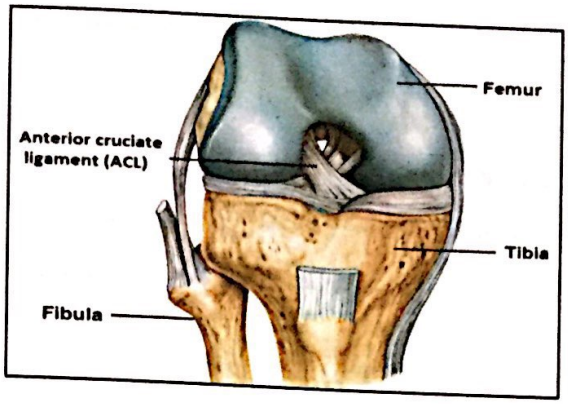


Figure 2.5: The Knee and ACL (rear view of the knee)

f) PCL Tear. Tearing of the posterior cruciate ligament of the knee (PCL) typically following knee hyperextension, or a direct blow to the front of the shin (figure 2.6). Often associated with a 'snap', 'pop' or 'tearing' sensation at the time of injury and poorly defined knee pain often most prominent at the back of the knee. Swelling may be minimal and there may be a feeling of knee instability, giving way or a 'jelly-like' feeling in the knee during certain movements.

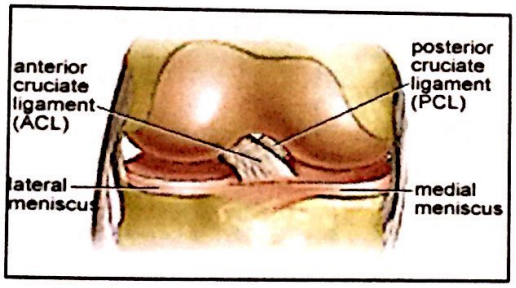


Figure 2.6: Anatomy of a PCL tear (rear view of the knee)

g) Dislocation Movement of the knee cap completely out of its normal position (usually to the outer aspect of the knee) typically following trauma such as a landing from a jump, a twisting movement or a direct blow to the side of the knee cap. May also occur without trauma particularly in young girls who are hyper mobile. Usually associated with severe pain at the front of the knee, deformity, loss of function and often swelling.

2.3.4 Type of Less Common Sudden Onset Injuries

a) LCL Tear. Tearing of the lateral collateral ligament of the knee (LCL) typically following a varus force or twisting movement and often associated with a snap or tearing sensation at the time of injury (figure 2.7).

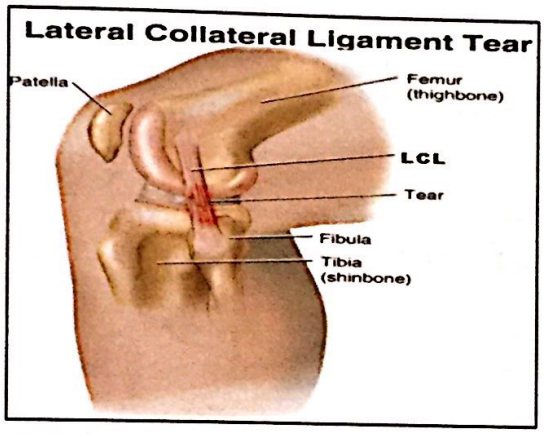


Figure 2.7: Anatomy of an LCL tear

b) Associated with knee pain located at the outer aspect of the knee, pain on firmly touching the LCL and often swelling. Occasionally associated with knee instability or giving way of the knee (figure 2.8).

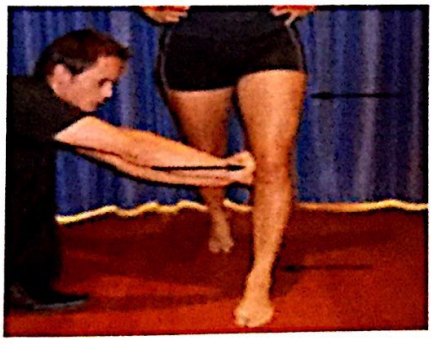


Figure 2.8: Varus force (often involved in a LCL tear)

c) Acute Patellofemoral Joint Injury. Damage to the knee cap (patella) or cartilage lining the joint between the knee cap and thigh bone (femur) often due to a fall onto the knee cap or direct blow to the front of the knee. Pain is usually felt at the front of the knee and may increase during weight-bearing, squatting or kneeling activities (figure 2.9).

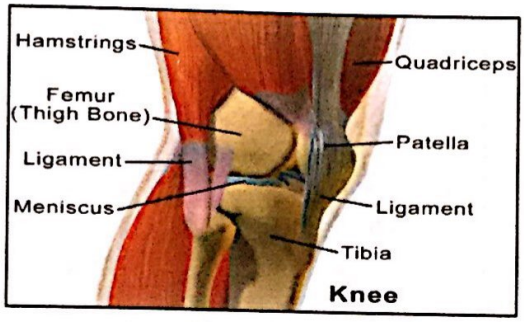


Figure 2.9: Anatomy of a Patellofemoral Joint Injury

d) Referred Pain. Pain referred to the knee from another source such as the lower back or hip joint, often associated with symptoms above or below the knee (such as lower back pain or stiffness or pain in the hip, buttock, groin, thigh, lower leg, ankle or foot). Typically associated with pain on firmly touching the region responsible for the referred pain or loss of movement in that region. Sometimes in association with pins and needles or numbness in the affected leg or foot.

e) Acute Fat Pad Impingement. Compression of fatty tissue located at the front of the knee directly below the knee cap, usually due to a knee hyperextension injury. Typically associated with significant knee pain, pain on firmly touching the region directly below the knee cap and exacerbation of symptoms during knee extension activities.

f) Low Quadriceps Contusion. Bruising of the lower aspect of the front of the thigh (quadriceps) following a direct impact from an object or person. Typically associated with pain on firmly touching the affected region (figure 2.10).

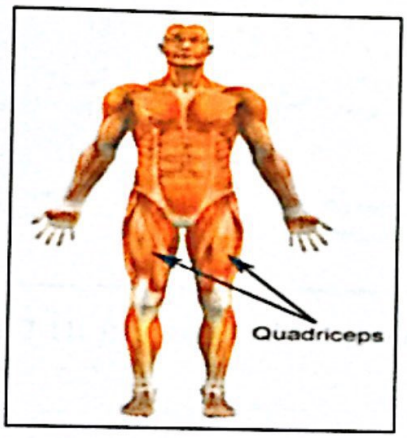


Figure 2.10: The Quadriceps muscle

g) Patellar Tendon Rupture. Rupture of the patellar tendon associated with sudden onset pain in the front of the knee often with an associated 'snap' or 'tearing' sensation at the time of injury (figure 2.11). Usually due to a specific incident such as a landing from a jump or when stumbling. Associated with marked loss of function such as an inability to stand or straighten the knee. Swelling and loss of fullness at the front of the knee is typically present. The kneecap (patella) is fixed firmly in the middle of the large tendon that attaches of thigh muscles (quadriceps) to the bone just below knee joint at the front of shin bones. The underside of kneecap is also covered with cartilage. The joint is surrounded by a membrane (the synovium synovium) that produces a small amount of synovial fluid, which helps to nourish the cartilage and lubricate the joint. The synovium has a tough outer layer called the capsule, which helps hold knee in place.[8]

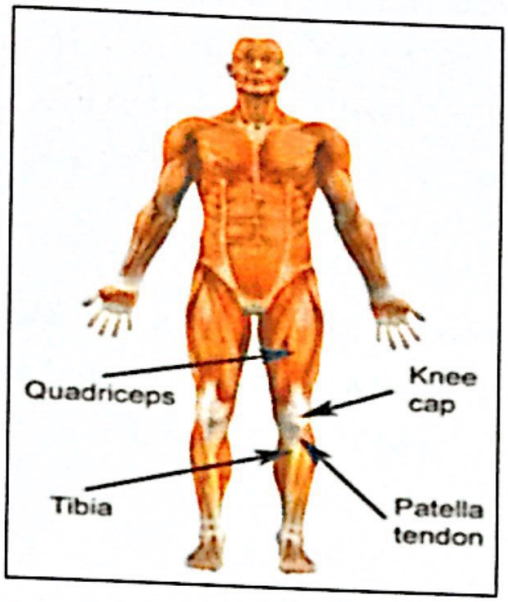


Figure 2.11: Patellar Tendon Anatomy

h) Superior Tibiofibular Joint Dislocation. Separation of the joint where the outer lower leg bone (fibula) joins the inner lower leg bone (tibia) just below the knee joint at the outer aspect of the knee (superior tibiofibular joint) (figure 2.12). Typically, due to traumatic forces such as a direct blow and associated with significant knee pain, deformity and swelling. Pain may also increase when firmly touching the affected region.

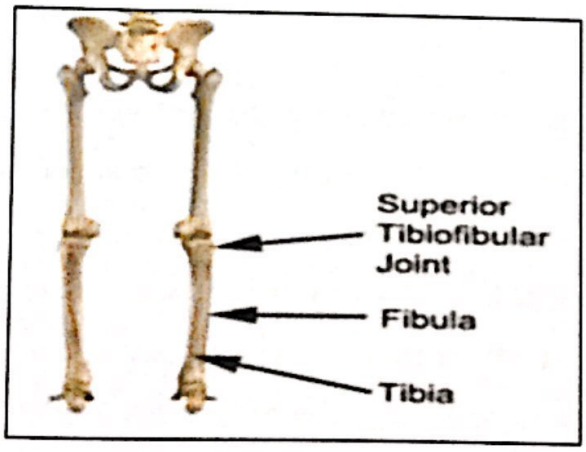


Figure 2.12: Superior Tibiofibular Joint Anatomy

i) Patellar Fracture. A break in the knee cap bone (patella) usually due to a fall onto the knee cap or a direct blow to the front of the knee. Associated with severe knee pain, loss of function, swelling and pain on firmly touching the affected region of the bone.

j) Tibial Plateau Fracture. A break in the upper aspect of the shin bone (tibia), usually due to a fall from a height. Pain is usually severe and often results in an inability to weight-bear.

2.4 Ankle Injuries

The tibiotalar joint is considered a simple hinge joint but it is much more complex due to its articular, ligamentous and tendinous anatomy. The lateral ankle ligament complex consists of three ligaments such as the anterior talofibular ligament (ATFL), the calcaneofibular ligament (CFL) and the posterior talofibular ligament (PTFL). The ATFL blends with the ankle capsule and runs from the antero-inferior margin of the fibula to the lateral margin of the talus inserting near the junction of the talar body and neck. The CFL originates on the inferior margin of the fibula distal to the ATFL and runs underneath the peroneal tendons to insert on the lateral tubercle of the calcaneus. The PTFL is a thickening of the capsule from the posterior fibula to the lateral tubercle of the posterior process of the talus.[10]

The lateral ankle ligament complex consists of the anterior talofibular ligament (ATFL), the calcaneofibular ligament (CFL), and the posterior talofibular ligament (PTFL). They provide lateral stability to the ankle joint, which is more complex than a simple rolling hinge joint. As the talus rotates internally and externally within the mortice of the ankle as the joint moves, a single ligament on the lateral aspect of the ankle would not be able to provide stability at all the positions of the tibiotalar joint. Three terms 'ankle ligament laxity', 'lateral ankle instability' and 'chronic ankle instability' are often used interchangeably. Laxity is a physical sign that is objectively detected on examination. Lateral ankle instability is a symptom, which identifies the

presence of an unstable ankle resulting from lateral ligamentous injury. The patient with such instability may describe a feeling of the ankle giving way. Meanwhile chronic ankle instability refers to repeated episodes of instability that result in recurrent ankle sprains.[11]

2.5 Diagnostic Guide of Ankle Pain

Patients suffering from ankle pain are commonly seen in physiotherapy practice. Pain is usually caused by local structures within or around the ankle, however, in rare cases, pain may be referred from other sources (such as the lower back) (figure 2.13).

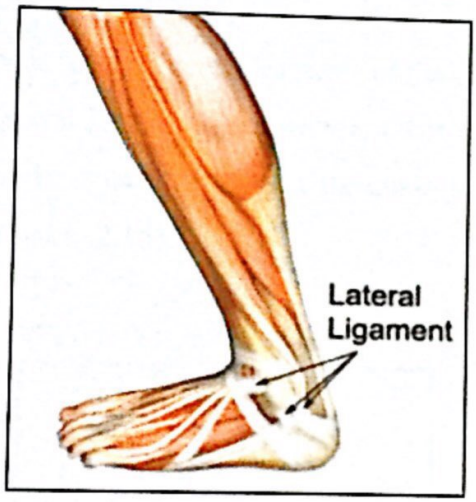


Figure 2.13: Ankle Pain Anatomy

The most common mechanism of injury in patients suffering from sudden onset ankle pain is a 'rolled ankle'. This is typically due to an inversion movement whereby the foot and ankle turn inwards relative to the lower leg (figure 2.14).

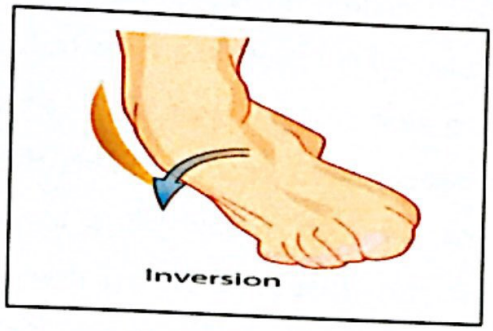


Figure 2.14: Ankle Inversion

In these instances, damage to the lateral ligament of the ankle most commonly occurs (Sprained Ankle and Lateral Ligament). However, other structures may also be involved, such as the shock absorbing cartilage within the ankle joint, peroneal muscles or local bones (i.e. a fracture) (figure 2.15).

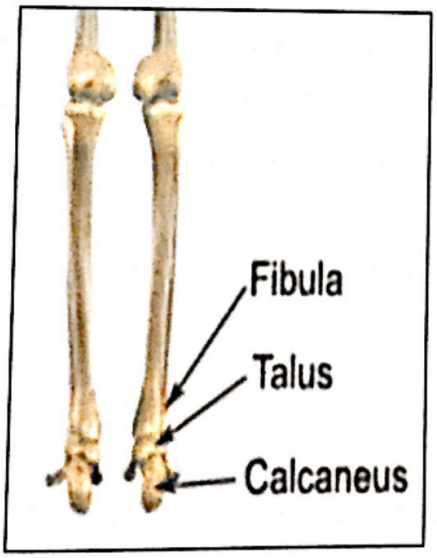


Figure 2.15: Bones of the Ankle

Gradual onset ankle pain often occurs in those patients involved in sports or activities that involve excessive walking or high running loads (particularly with rapid changes of direction, on uneven surfaces or in inappropriate footwear). In these cases, overuse injuries to the tendons around the ankle are common. One of the most common causes of gradual onset pain located at the front of the ankle is Tibialis Anterior Tendonitis . Patients with gradual onset pain located at the outer aspect of the ankle are often due to Peroneal Tendonitis, whilst those suffering from gradual onset pain located at the inner aspect of the ankle are often due to Tibialis Posterior Tendonitis. Patients with gradual onset pain located at the back of the ankle are often due to Achilles Tendonitis. In older patients with gradual onset ankle pain, the most likely cause of symptoms may be degenerative changes in the ankle, such as Ankle Arthritis.

2.5.1 Consist Three of Type Sudden Onset Ankle Pain

a) **Lateral Ligament Sprain**. Tearing of the lateral ligament of the ankle typically following a rolled ankle (inversion Injury). Associated with outer ankle pain, pain on firmly touching the lateral ligament of the ankle pain on turning the foot and ankle inwards excessively (inversion) often swelling or bruising. Arguably the most common cause of acute outer ankle pain. Ankle sprains are one of the most common soft-tissue injuries and are especially prevalent at all levels of sport, with lateral sprains accounting for 85% of all such injuries. Inversion injuries involve about 25 % of all injuries of the musculoskeletal system, and about 50 % of these injuries are sport related. In the systematic review of Fong et al., the ankle was the most commonly injured area of the body in 24 of 70 sports included the majority of ankle sprains occur in individuals under 35 years of age, most commonly in those age 15–19 years.[10]

b) **Osteochondral Lesion of the Talar Dome.** Damage to cartilage or bone located at the top of the talus bone, usually due to compressive forces such as a landing from a jump and often in association with a rolled ankle (figure 2.16). Symptoms may increase during weight bearing activities such as excessive walking or running (especially up hills or on uneven surfaces) or during hopping or jumping. Pain may also increase on firmly touching the region of the talus bone, often at the front of the ankle.

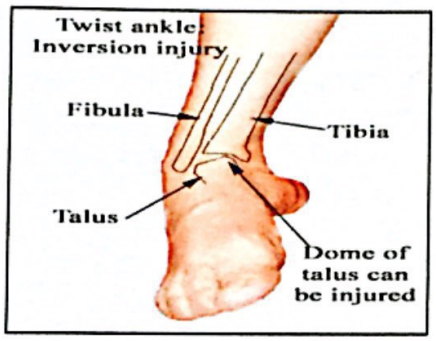


Figure 2.16: Talus Region (May be tender to firmly touch in patients with an Osteochondral Lesion of the Talar Dome).

c) **Medial Ligament Sprain.** Tearing of the medial ligament of the ankle typically following a rolled ankle (eversion Injury) (figure 2.17). Associated with inner ankle pain, pain on firmly touching the medial ligament of the ankle, pain on turning the foot and ankle outwards excessively (eversion) and often swelling or bruising.

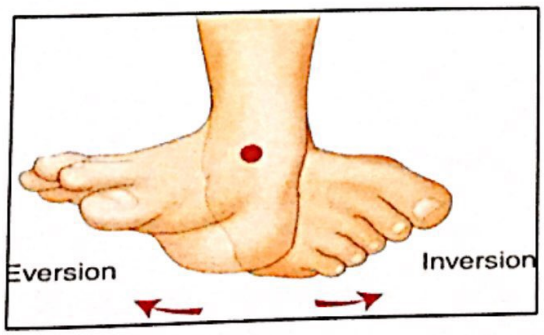


Figure 2.17: Eversion of the ankle

2.5.2 Consist Type 10 of Less Common Sudden Onset Injuries

a) **Distal Tibiofibular Joint Injury**. Tearing of connective tissue holding the tibia and fibula bones together just above the ankle, typically in association with more severe ankle injuries (figure 2.18). Often associated with significant pain usually at the front of the ankle, reduced function and tenderness on firmly touching the affected region.

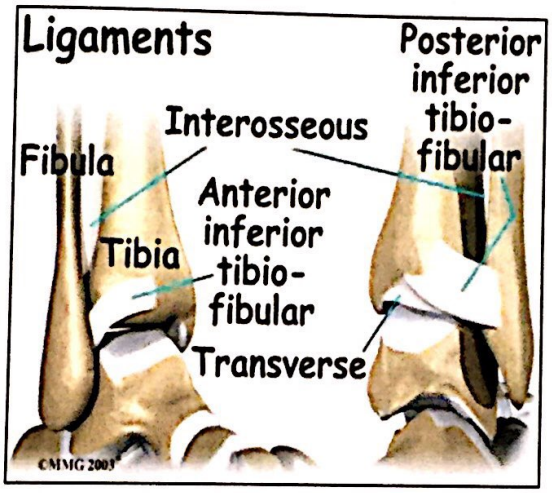


Figure 2.18: Distal Tibiofibular Joint Region (May be tender to firmly touch in patients with a Distal Tibiofibular Joint injury).

b) **Lateral Malleolus Fracture**. Fracture of the bony process at the outer aspect of the ankle usually due to traumatic forces (e.g. landing from a height) often in association with a rolled ankle (figure 2.19). Associated with significant outer ankle pain (particularly during weight bearing), swelling and tenderness on firmly touching the affected region of the bone (Lateral Malleolus).

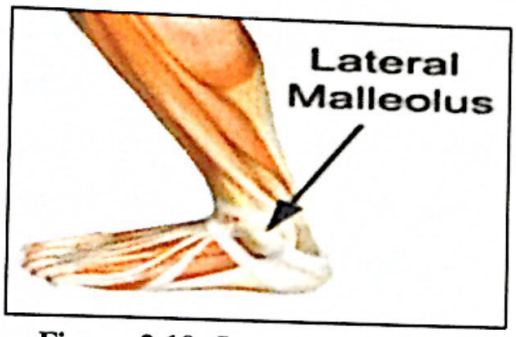


Figure 2.19: Lateral Malleolus

c) **Medial Malleolus Fracture**. Fracture of the bony process at the inner aspect of the ankle usually due to traumatic forces (e.g. landing from a height) often in association with a rolled ankle (figure 2.20). Associated with severe inner ankle pain (particularly during weight bearing), swelling and tenderness on firmly touching the affected region of the bone.

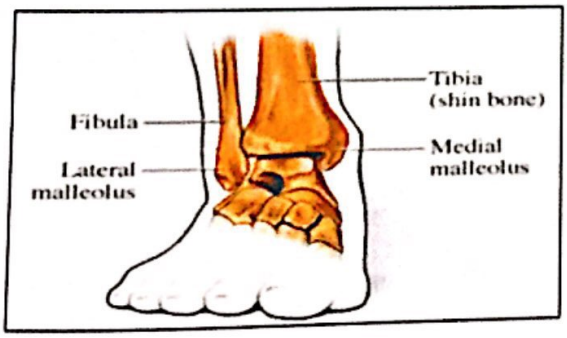


Figure 2.20: Medial Malleolus

d) **Talus Fracture**. Fracture of the talus bone usually due to traumatic forces (e.g. landing from a height) and associated with severe pain often at the front or sides of the ankle (particularly during weight bearing) and swelling. Pain may also increase on firmly touching the talus bone, often at the front of the ankle.

e) **Pott's Fracture**. Fracture of one or more bony processes located at the sides of the ankle (e.g. the medial and lateral malleolus) usually due to traumatic forces such as landing from a height or in association with a severe ankle sprain. Associated with severe pain (particularly during weight bearing), swelling, sometimes deformity and tenderness on firmly touching the affected region of bone.

f) **Dislocated Ankle**. Separation of the ankle joint due to traumatic forces (e.g. motor vehicle accident / fall from a height) with severe pain, loss of function, swelling, deformity and often associated with one or more fractures.

g) **Peroneal Tendon Subluxation**. Movement of the peroneal tendon out of its normal position causing a sensation of the tendon flicking in and out of position at the outer aspect of the ankle (over the lateral malleolus) during certain movements (figure 2.21). Associated with pain or ache located at the outer aspect of the ankle often with swelling, bruising and tenderness on firmly touching the peroneal tendon.

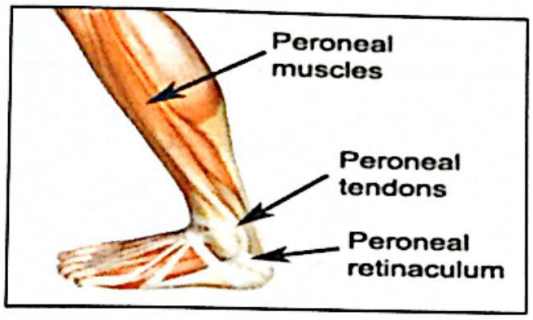


Figure 2.21: Peroneal Tendon Anatomy

h) **Peroneal Tendon Rupture**. Rupture of one or more peroneal tendons associated with sudden onset pain in the outer aspect of the ankle usually due to a specific incident followed immediately with loss of function and significant weakness on attempted ankle eversion. A snap or tear may be audible during injury. Swelling, bruising and tenderness on touching the tendon is typically present.

i) **Tibialis Posterior Tendon Dislocation**. Movement of the tibialis posterior tendon out of its normal position causing a sensation of the tendon flicking in and out of position at the inner aspect of the ankle (over the medial malleolus) during certain movements (figure 2.22). Associated with pain or ache located at the inner aspect of the ankle often with swelling, bruising and tenderness on firmly touching the tibialis posterior tendon.

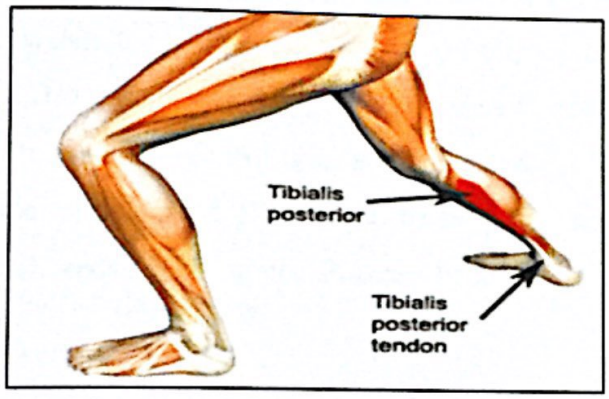


Figure 2.22: Tibialis Posterior Tendon Anatomy

j) **Tibialis Posterior Tendon Rupture**. Rupture of the tibialis posterior tendon associated with sudden onset pain in the inner aspect of the ankle usually due to a specific incident, followed immediately with marked loss of function, weakness on attempting a heel raise and later an observable drop in height of the inner arch of the foot during weight bearing. A snap or tear may be audible during injury. Swelling, bruising and tenderness on firmly touching the tendon is typically present.

2.6 Type of Led

2.6.1 Blue Led

The Celluma panel has approximately 115 Blue light emitting diodes that emit energy in the blue portion (465 nanometers) of the visible light spectrum. Blue LED is FDA cleared to treat Inflammatory Acne Vulgaris. *P. acnes* is the bacteria that causes acne, and it is known to produce a large amount of porphyrins within the bacterial cell. These porphyrins can be photosensitized with Blue LED to create an oxygen molecule. *P acnes* is some anaerobic bacteria, which means it cannot live in the presence of oxygen. So when *P. acnes* is in the presence of Blue LED these porphyrins create an oxygen molecule, which ends up killing the P. acnes bacteria.

Clinical studies on the influence of LLLT on wound healing, including the remodelling phase, demonstrated the positive effects of irradiation on the healing of post-operative aseptic wounds and on burn wounds, concerning macroscopic appearance, pruritus and pain. Most of these studies were performed with red or infrared laser irradiation, however other wavelengths may also have a positive effect on wound healing. We recently showed that blue light (470 nm) can significantly influence biological systems, improving tissue perfusion by release of nitric oxide from nitrosyl complexes with haemoglobin in a skin flap model in rats.

Despite the positive consequences of lasers on wound healing this kind of devices are expensive, require high energies and may cause significant patient discomfort. Recently, light emitting diodes (LED) have been presented as a comfortable, potentially highly selective light source for the therapy of many indications. Led are small, robust devices that emit a narrow band of

electromagnetic radiation ranging from ultraviolet to visible and infrared wavelengths. LED usually generate low-intensity light in the millwatt range, and can be configured on small chips or connected to small lamps. Klebanov etal. compared coherent laser and non-coherent light emitting diodes and found that they both had very close effects on wound[12]

Figure 2.23: The Blue, or Acne, setting on the Celluma LED panel.

2.6.2 Red Led

The Celluma panel has approximately 115 Red light emitting diodes that emit energy in the red portion of the visible light spectrum (640 nanometers). Red LED penetrates deep into the layers of the skin, to a depth of 8 – 10 mm. Red LED is beneficial in healing inflamed acne, wounds, cuts, scars and infections. It is also recommended as a post-care treatment after fractional laser, dermal rolling or needling, chemical peels, electrodessication and micro or dermabrasion.

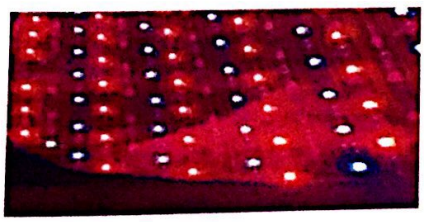


Figure 2.24: The Red setting on the Celluma LED panel is useful in anti-aging treatments.

2.6.3 Near Infrared Led

The Celluma panel has approximately 115 Infrared light emitting diodes that emit energy in the near infrared portion of the light spectrum (880 nanometers). Infrared is invisible to the naked eye, but if you look at the lit panel you will see 4 green LED on the 4 corners of the panel. These are indicator lights showing you that your Infrared setting is indeed working. Infrared LED penetrates deeper into the skin, to a depth of about 25 mm. Infrared is also beneficial in healing wounds, cuts, scars and infections along with stimulating the deeper tissues, resulting in a healing effect on muscles deep in the subcutaneous tissues.

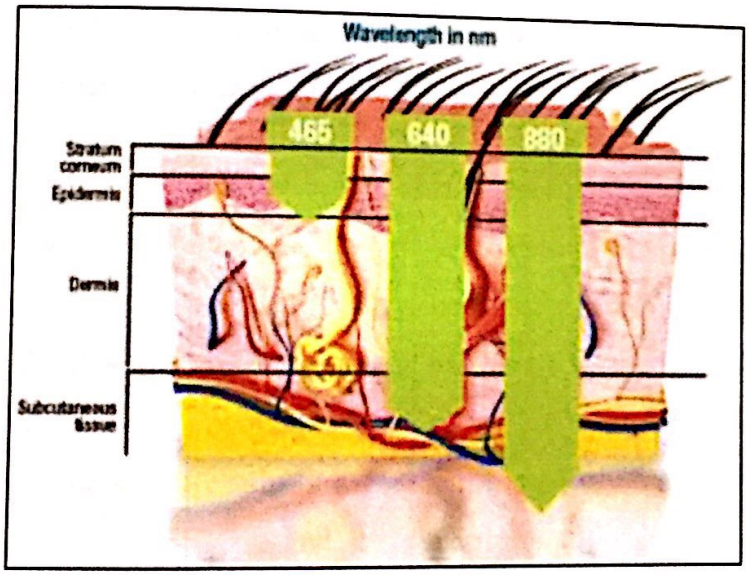


Figure 2.25: layer of skin and penetrate

2.7 Distinguish of Device

Table 2.1 show comparison between cold laser device, acupuncture device, ultrasound device and electrical stimulation device. All device compare between seven characteristics such as pain control, benefits, tissue affected, treatment times, body contact, patient comfort and patient restriction.

Table 2.1: Comparison between four device

	Cold Laser	Acupuncture	Ultrasound	Electrical Stimulation
Pain Control	Joint, Head, Migraines, Muscular	Joint, Head, Migraines, Muscular	Joint, Muscular	Muscular
Benefits	Increase circulation, faster healing. May reduce inflammation. May permanently eliminate acute and chronic pain.	Increase circulation, faster healing. May permanently eliminate acute and chronic pain	High-energy sound waves penetrate deep into tissue to cause tissue/muscle warming, increased vessel vasodilatation and increase circulation. Short-term changes in cell membrane permeability.	Electrical stimulation produces a mild current that can prevent pain messages from being transmitted to the brain. May raise the level of endorphins

Tissues Affected	Absorbed by all tissues including skin, subcutaneous, tendons, muscles, and nerves	Direct tissue contact, may result in bruising and bleeding	Absorbed by white connective tissue	Muscle tissue only
Treatment Times	2-6 Minutes	20-60 Minutes	5-8 Minutes	15-20 Minutes
Body Contact	Dry contact	Penetration of skin	Requires gel or water medium	Requires Electrodes
Patient Comfort	Soft sensation or no sensation (may feel warm)	May experience pain or spasms while needles are in place	Discomfort with excess heating of tissues (especially if not moving electrode)	Mild to severe discomfort with tingling and potential burning
Patient Restriction	Do not use over suspicious or cancerous lesions, or on pregnant women	Do not use on suspicious or cancerous lesions, or on pregnant women	Not for use with patients with circulation or neuropath conditions, pacemakers, cancer, or pregnant women	Not for use with patients with circulation or neuropath conditions, pacemakers, cancer, or pregnant women

CHAPTER 3

METHODOLOGY

3.1 Introduction

The Muscle Pain Therapy is the treatment muscle pain for sport player injury. It has wavelength of light used, which is usually in the 630 nm to 980 nm ranges of the electromagnetic spectrum. This wavelength allows for the least energy to be absorbed by surface tissue (meaning that the patient does not experience any sensation of heat or warming), while allowing the healing properties of the light to facilitate wound and tissue healing. When cells are exposed to NIR Led light, cell functions are stimulated, improving immune system function, increasing collagen synthesis and enhancing tissue regeneration. It uses of muscle pain therapy also accelerates the healing of connective tissue disorders such as sprains, strains and tendinitis, and has proven effective in reducing or managing chronic or acute pain in the neck, thoracic regions or lower back. Red Led have also been used to effectively treat muscle injuries or bruises, and neurological injuries such as herniated or ruptured discs.

3.2 Design Muscle Pain Therapy

3.2.1 Design Overview

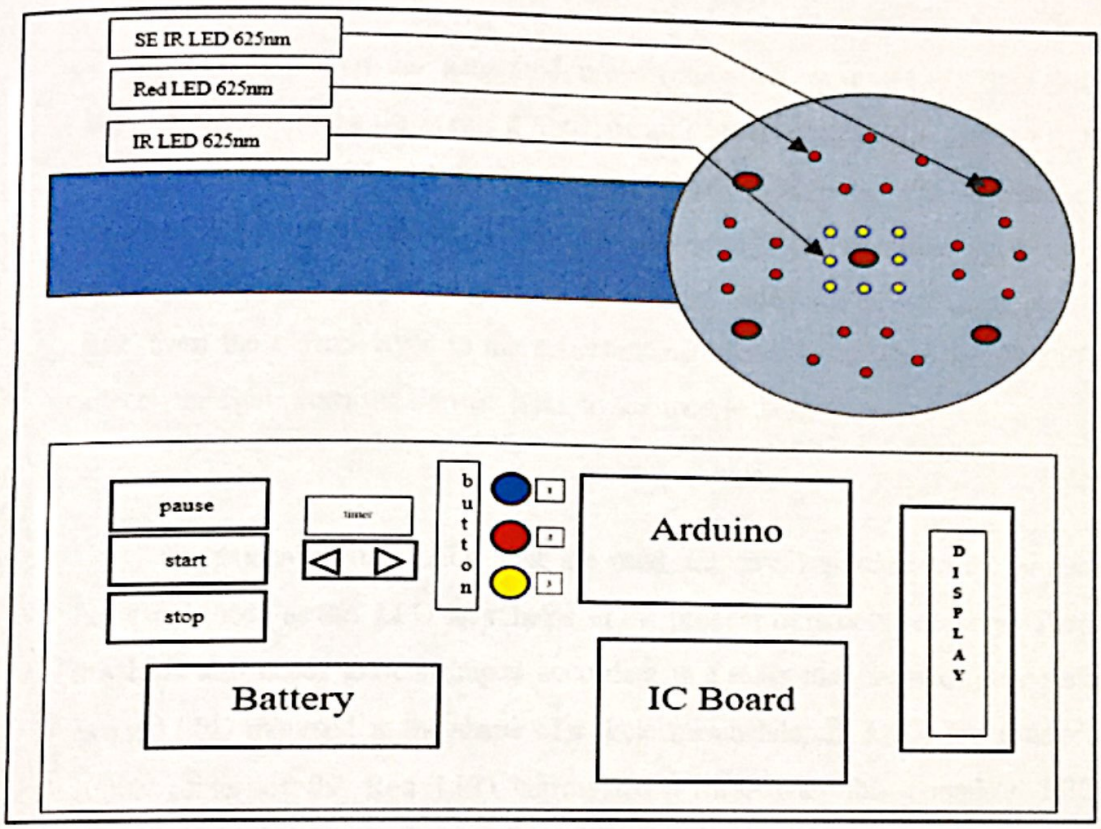


Figure 3.1: Sketch of design Muscle Pain Therapy

This figure shows the design of muscle pain therapy. This design takes from research from other device to recovery the muscle. This design created before produce the prototype of device.

3.3 Hardware

3.3.1 Explanation of LED

First of all, for this generated project uses two types of LED. The LED is red LED and LED IR. Next, it also has a different wavelength of red LEDs using the 625nm while IR LEDs use the 860nm. Therefore, this wavelength determines the impact on muscle recovery for sport player or athlete injuries. In addition, this LED also has a capacity of different skin such as red LEDs giving light from the dermis layer to the subcutaneous tissue layer while the IR LED affects the light from the dermis layer to the muscle layer.

Additionally, the LEDs that are used are very important to the project being produced as this LED light helps in the process of muscle recovery. Then, this LED also needs to be arranged according to a study that has been done such as a red LED mounted in the shape of a circle meanwhile, IR LEDs are arranged in the center of the Red LED surrounded. Thus, with this complete LED arrangement, it helps to accelerate the process of muscle recovery.

3.3.2 Type of Led

This project uses two types of LEDs that are very suitable in assisting the muscle recovery process. Additionally, the used LED has a very large output of 25 LEDs that have been used in the project. It has two types of LEDs and different wavelengths refer to figure 3.2 and figure 3.3. In addition, LEDs are used has a different capacity in the production of light. Furthermore, the total number of LEDs used is very high, 16 total red LEDs have been used while 9 total of LED IR are used on this device.

Figure 3.2: Red LED 625nm 5mm

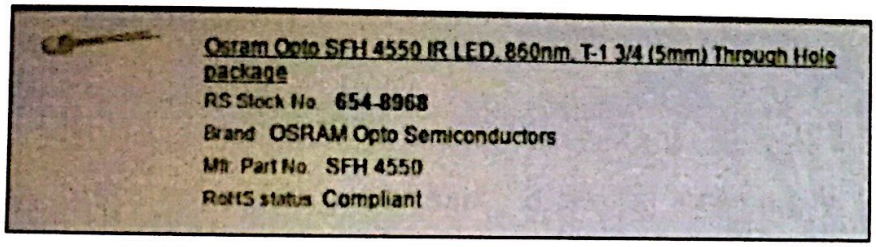


Figure 3.3: IR LED 860nm 5mm

3.3.3 Arduino

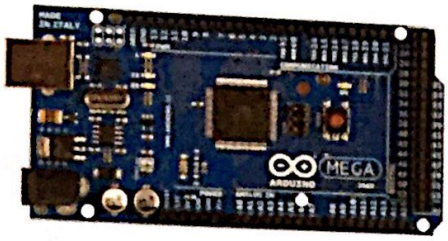


Figure 3.4: Arduino 2560

The Arduino mega that used in this project is a Arduino Mega 2560. It is a microcontroller board based on the ATmega2560 (datasheet). It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller simply connect it to a computer with a USB cable or power it with a AC to DC adapter or battery to get started. The Mega is compatible with most shields designed for the Arduino Duemilanove or Diecimila.[13]

The Arduino Mega can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC to DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. The Mega2560 differs from all preceding boards in that it does not use the FTDI USB toserial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter.

3.3.4 Battery

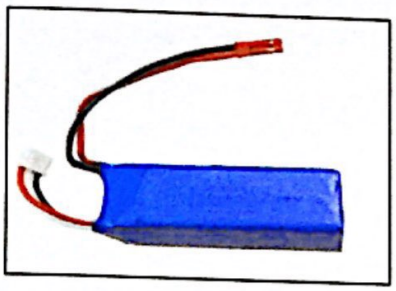


Figure 3.5: LiPo Battery

Lithium Polymer batteries (henceforth referred to as "LiPo" batteries), are a newer type of battery now used in many consumer electronics devices. They have been gaining in popularity in the radio control industry over the last few years and are now the most popular choice for anyone looking for long run times and high power (figure 3.5). LiPo batteries offer a wide array of benefits, but each user must decide if the benefits outweigh the drawbacks. There is nothing to fear from LiPo batteries. It is accurate and it can make it without actually being a chemical engineer. In the research about lipo battery, it can guide isn't intended to be taken as definitive. It is a living document and as common knowledge regarding LiPo batteries changes, so too will this guide. After that, the differences between LiPo batteries and their Nickel-Cadmium as well as Nickel-Metal Hydride counterparts. Lastly, this battery use 1200mAh and 7.4v.

3.3.5 Button

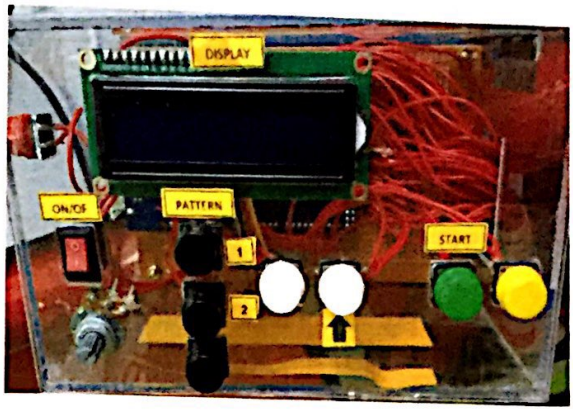


Figure 3.6: image button

This project uses a type of push button option to control all function on the device. That causes, push buttons are more suitable for use on this project than other types of buttons. Type for this push button consist of a simple electric switch mechanism which controls some aspect of a machine or a process. Buttons are typically made out of hard material such as plastic or metal. The surface is usually shaped to accommodate the human finger or hand, so the electronic switch can be easily depressed or pushed. Furthermore, most push button switches are also known as biased switches. A biased switch, it can be also considered what we call a "momentary switch" where the user will push for "on" or push for "off" type. This is also known as a push to make or push to break mechanism. Switches with the "push-to-make" (normally-open or NO) mechanism are a type of push button electrical switch that operates by the switch making contact with the electronic system when the button is pressed and breaks the current process when the button is released. An example of this is a keyboard button.

3.3.6 Compact Charger

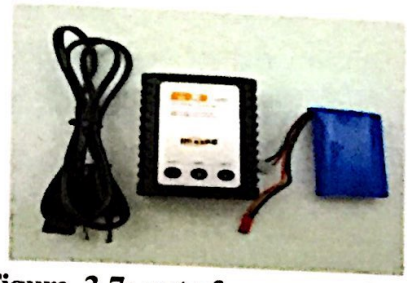


Figure 3.7: set of compact charger

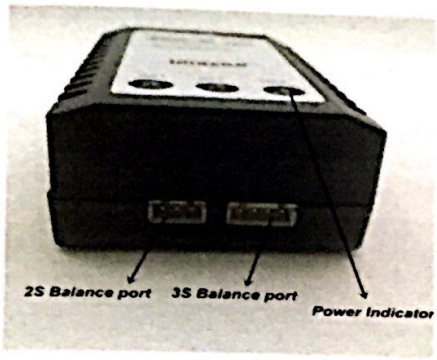


Figure 3.8: image top view

Figure 3.9: image behind view

Compact charger is use for charging of LiPo battery. The compact charger B3 Pro has internal 100-240V AC switch power is built in and the high precision balance circuit can supply larger current up to 850mA series. Furthermore, double colour LED can display the process of charging (Red means of charging and Green that means as full). This charger is compact and light, especially there is separated corresponding balance port for each battery pack. It has wide power cord slot and suitable balance port to used.

3.3.7 Testing

This test is conducted to identify whether the electronic components to be used on the project can function properly or otherwise be damaged. Therefore, this tested will make sure all component that will be used to function properly without any damaged. Then, the testing process for these electronic components was very important before through the next process. Furthermore, before conducting the soldering process for each electronic component on the IC board, it was necessary to do a test first on the portable board. For example, testing flames of LED and functional of programming on a portable board refer to figure 3.10. After that, when receiving the results of analysis for all these electronic components, it can be directly connected to the soldering process.

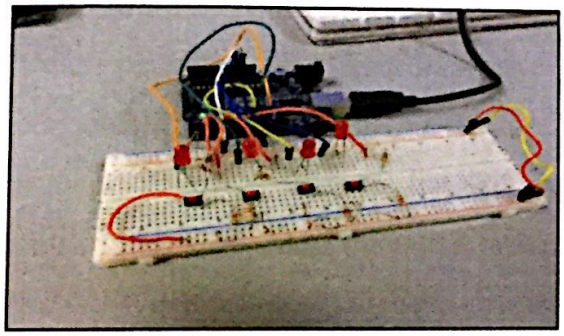


Figure 3.10: Testing Arduino Program on Board

3.4 Software

3.4.1 Arduino Mega 2650 (Run Program)

Arduino has been used in thousands of different projects and applications. The Arduino software is easy to use for beginners, yet flexible enough for advanced users. It runs on Mac, Windows, and Linux. Teachers and students use it to build low cost scientific instruments, to prove chemistry and physics principles, or to get started with programming and robotics. Designers and architects build interactive prototypes, musicians and artists use it for

installations and to experiment with new musical instruments. Makers, of course, use it to build many of the projects exhibited at the Maker Faire, for example. Arduino is a key tool to learn new things. Anyone children, hobbyists, artists, programmers can start tinkering just following the step by step instructions of a kit, or sharing ideas online with other members of the Arduino community. There are many other microcontrollers and microcontroller platforms available for physical computing. Parallax Basic Stamp, Netmedia's BX-24, Phidgets, MIT's Handyboard, and many others offer similar functionality. All of these tools take the messy details of microcontroller programming and wrap it up in an easy-to-use package. Arduino also simplifies the process of working with microcontrollers, but it offers some advantage for teachers, students, and interested amateurs over other systems.

Inexpensive. Arduino boards are relatively inexpensive compared to other microcontroller platforms. The least expensive version of the Arduino module can be assembled by hand, and even the pre-assembled Arduino modules cost less than $50. Cross platform, the Arduino Software (IDE) runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows. Simple, clear programming environment, the Arduino Software (IDE) is easy to use for beginners, yet flexible enough for advanced users to take advantage of as well. For teachers, it's conveniently based on the Processing programming environment, so students learning to program in that environment will be familiar with how the Arduino IDE works.

Open source and extensible software. The Arduino software is published as open source tools, available for extension by experienced programmers. The language can be expanded through C++ libraries, and people wanting to understand the technical details can make the leap from Arduino to the AVR C programming language on which it's based. Similarly, you can add AVR-C code directly into your Arduino programs if you want to.

3.4.2 Programming by Used Arduino

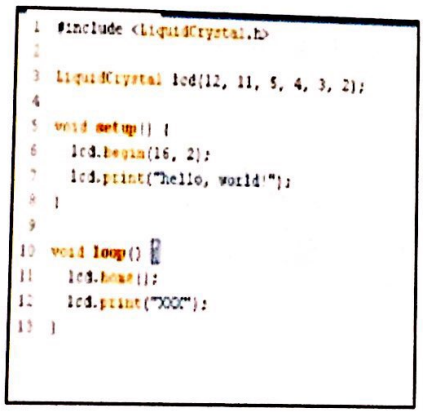
The Mega 2560 board can be programmed with the Arduino Software (IDE). For details, see the reference and tutorials. The ATmega2560 on the Mega 2560 comes preprogramed with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol.You can also bypass the bootloader and program the microcontroller through the ICSP (In Circuit Serial Programming) header using Arduino ISP or similar; see these instructions for details. The ATmega16U2 (or 8U2 in the revl and rev2 boards) firmware source code is available in the Arduino repository. The ATmega16U2/8U2 is loaded with a DFU bootloader, which can be activated by:

I. On Revl boards: connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2.

II. On Rev2 or later boards: there is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode. You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer (overwriting the DFU bootloader). See this user-contributed tutorial for more information.

Figure 3.11: Display LCD

Figure 3.11 show display of result Arduino programming. After execute the program from Arduino software, its show the result to LCD display. Display show "hello, world" from finish program execute at s Arduino software.



```
#include <LiquidCrystal.h>

LiquidCrystal lcd(12, 11, 5, 4, 3, 2);

void setup() {
  lcd.begin(16, 2);
  lcd.print("hello, world!");
}

void loop() {
  lcd.home();
  lcd.print("7000");
}
```

Figure 3.12: Coding

Figure 3.12 show command of Arduino programming. That is command that use for create the "hello, world" display. It need to create this command following the step by step.

3.5 Block Diagram

Figure 3.13 show step operation of muscle pain therapy device. It has six step operation of this device to achieve for the last step. It is start from battery rechargeable, switch on/off, select time, program Arduino, display LCD and the last step is LED functional. First of all, battery rechargeable which functions as an electrical energy store. Next the current flows from the battery to the device IC board circuit after the switch ON/OFF is open. After that, after the current flows in this device circuit, each control panel on this device is working properly. Next, it can select the time to set up the time for the treatment to the patient. Then, data from the selection for duration time will be sent to Arduino programming and then the message through be sent to the LCD display. After that, the message will appear on the LCD screen and the LED will continue work to treat patients according the designated duration.

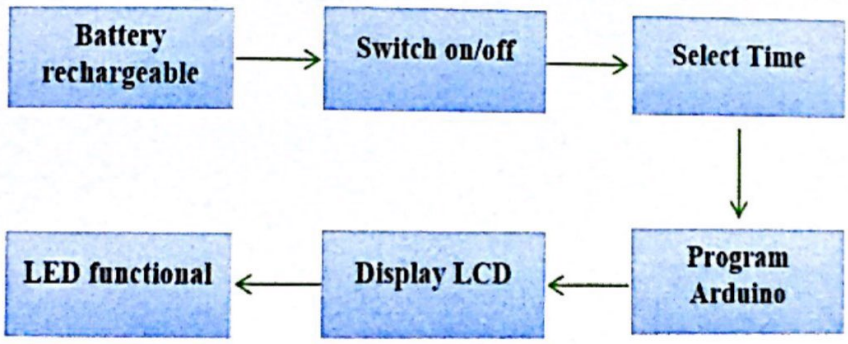


Figure 3.13: Block diagram

3.6 Flow Chart

Figure 3.14 show flow chart operation of muscle pain therapy device. This process start from "start", "collecting data to find problem statement", "design, programming and making hardware", "testing", "collecting data to produce result" and the last process is "end". Firstly, data collection is collected to recognize the problem statement, objective, scope of project and significant of project. After identify the chapter 1, literature reviews are important to enhance the knowledge about this project. The sources for this literature review are from the journals and articles. After that, designation of project by hardware and software should be discussed with supervisor. After get the endorsement about what a design should be to this project, the testing and stimulation will be run to get a data. If fail, recheck back at the software and hardware, if success proceed to the data analysis and display the result.

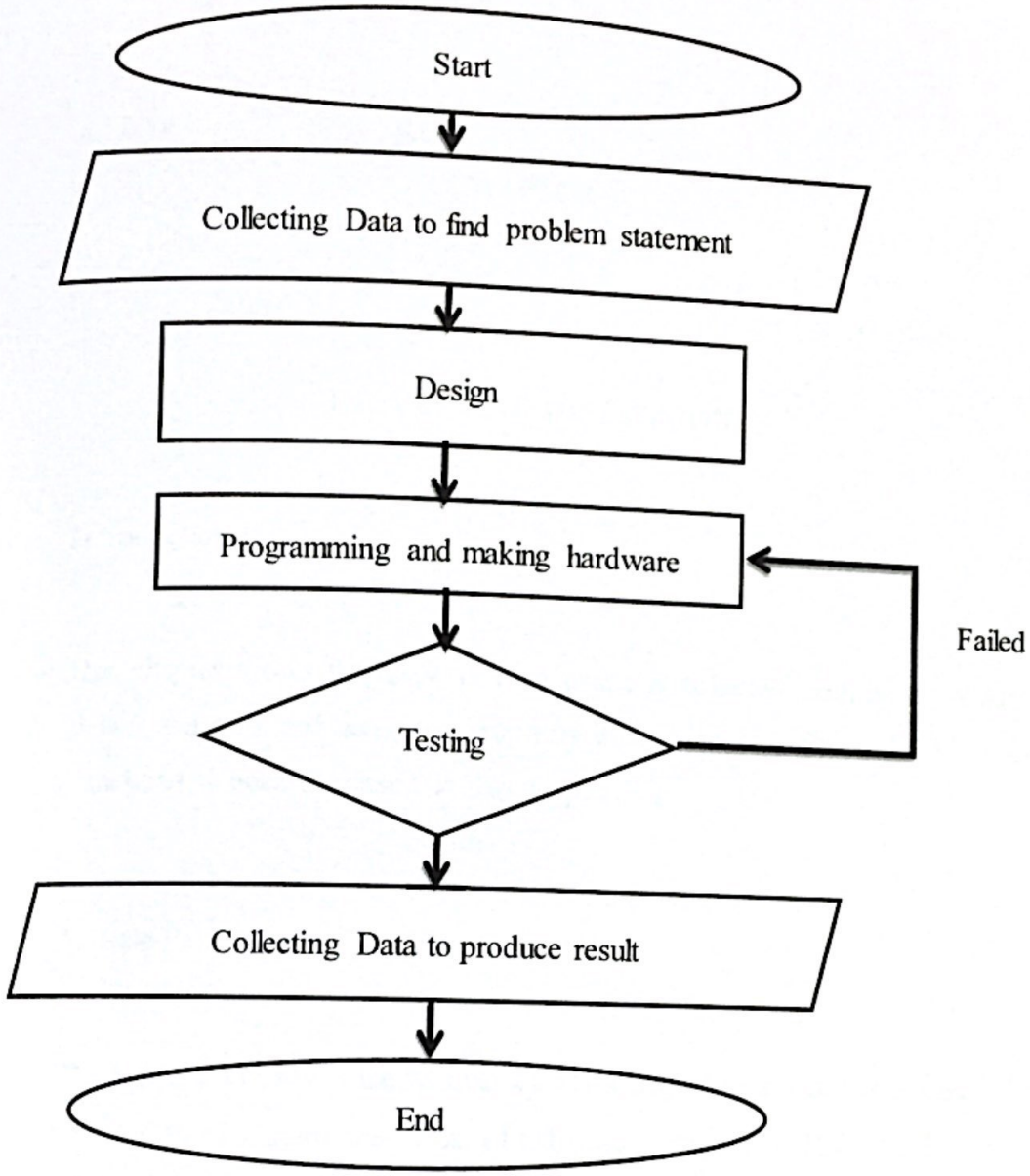


Figure 3.14: Flow Chart of Implementation of Project Muscle Pain Therapy

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This chapter shows the result of data which is collected such as questionnaire and the data is analysed and generated graph by using Microsoft Excel. Then the result which is analysed is been discussed in this chapter.

4.2 Muscle Pain Therapy

The figure 4.1 below is the Muscle Pain Therapy Device that has invented. This device provides three pattern selections of led which are pattern 1, 2, and 3. Besides, this muscle pain therapy device also functions as timer, which is used to set the number to increase and decrease up to 30 minutes. This device is portable and easy to bring to any place. It also has reset button for stop meanwhile start button function for continuing operation of treatment. This device use for treatment at muscle pain section with low level of pain. Next, the battery is rechargeable and can use for a long time period for patient treatment. In addition, it is also easily operated by the patient because every button that is used to control all function of this device is well organized and has a labelling on each button.

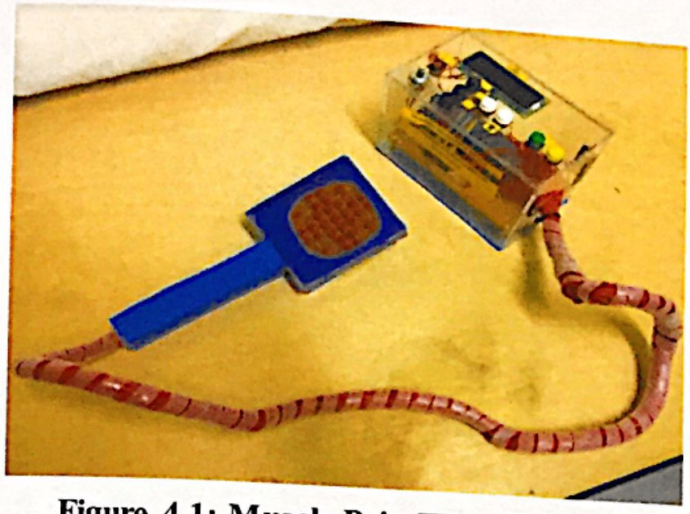


Figure 4.1: Muscle Pain Therapy Device

Furthermore, this developed device has an easy installation, where the devices only need to install the DC rechargeable batteries before implement the treatment. Compared with the existing devices, it has a complex of installation before provided the treatment. It also has a good safety controls to be applied to patients. Then, this developed Muscle Pain Therapy has two main parts, which are control panel and hand holder. The control panel contained reset button, ON/OFF button, increase button, decrease button, timer increase button, timer decrease button, start button, three pattern of light button and LCD displays. This Muscle Pain Therapy device used one batteries to operate the 12V DC rechargeable batteries. The 12 DC batteries used to control the light for treatment, to power up the control panel and provided the power to the LCD displays.

4.2.1 Diagram of Muscle Pain Therapy

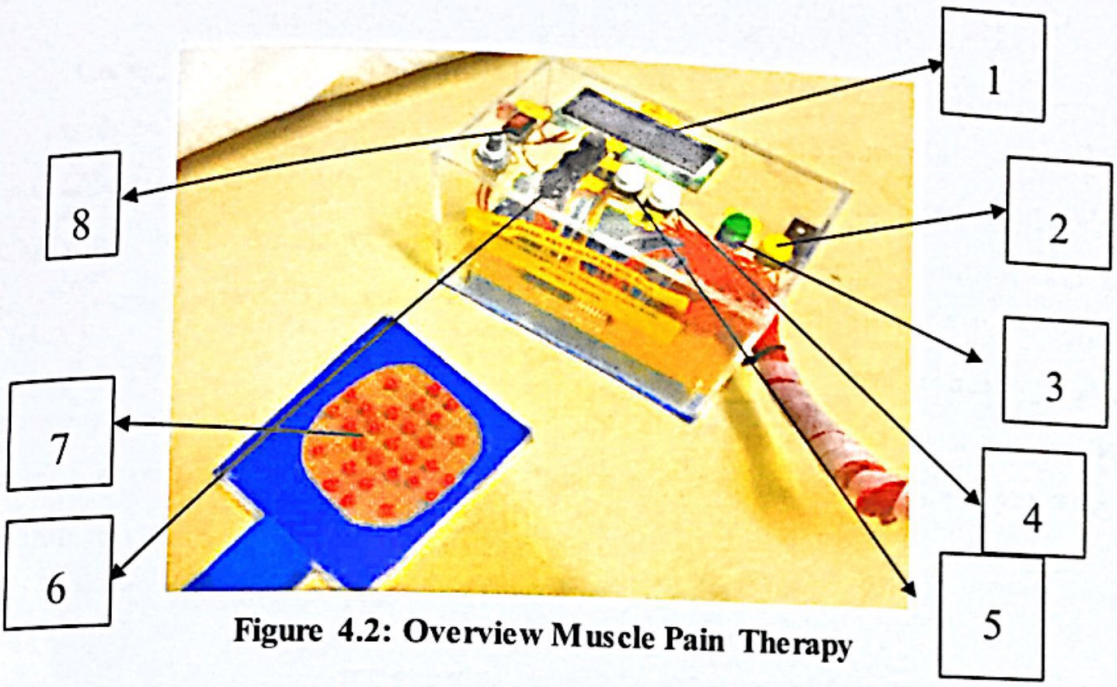


Figure 4.2: Overview Muscle Pain Therapy

Table 4.1: Function of control panel

NO	PARTS	FUNCTION
1	LCD display	Display timer, pause and reset
2	Button "pause"	Pause the operation
3	Button "Start"	Start the operation
4	Button "timer up"	Increase the number of timer
5	Button "timer down"	Decrease the number of timer
6	Button "pattern"	Change pattern 1,2,3 of Led light
7	LED Red light and IR LEd	Light was operation
8	Power switch "on/off"	ON and OFF the device

4.3 Usability Test

During testing the device, 20 normal subjects were tested, and questionnaires were distributed to them. Usability testing consists of three main items which are design, comfortableness and effectiveness. These 3 main items data were collected through the usability test, which the subject have carried out muscle pain therapy, then is answered through questionnaires. The subject is selected among football player in Polytechnic Sultan Salahuddin Abdul Aziz Shah. After the experiment is being carried out, the outcome shows the subject experienced injury at knee and ankle. Usability test is essential in order to prove data with appropriate regarding your device when some treatment is carried out.

Figure 4.3: Treatment at Ankle

Figure 4.4: Treatment at Knee

4.3.1 Design

The main items are Design of the developed device. The table 4.2 below shows the data collected from 20 subjects. That consist three question.

Table 4.2: Data of Design

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
The design is suitable to be use in everywhere	0	1	3	6	10
The design is light in weight	0	2	3	7	8
The design is easily to be carried	0	0	4	6	10

From the table 4.2 above shows the data of design, the data was collected and generated or analysis by using Microsoft Excel and the graph has shown in bar graph.

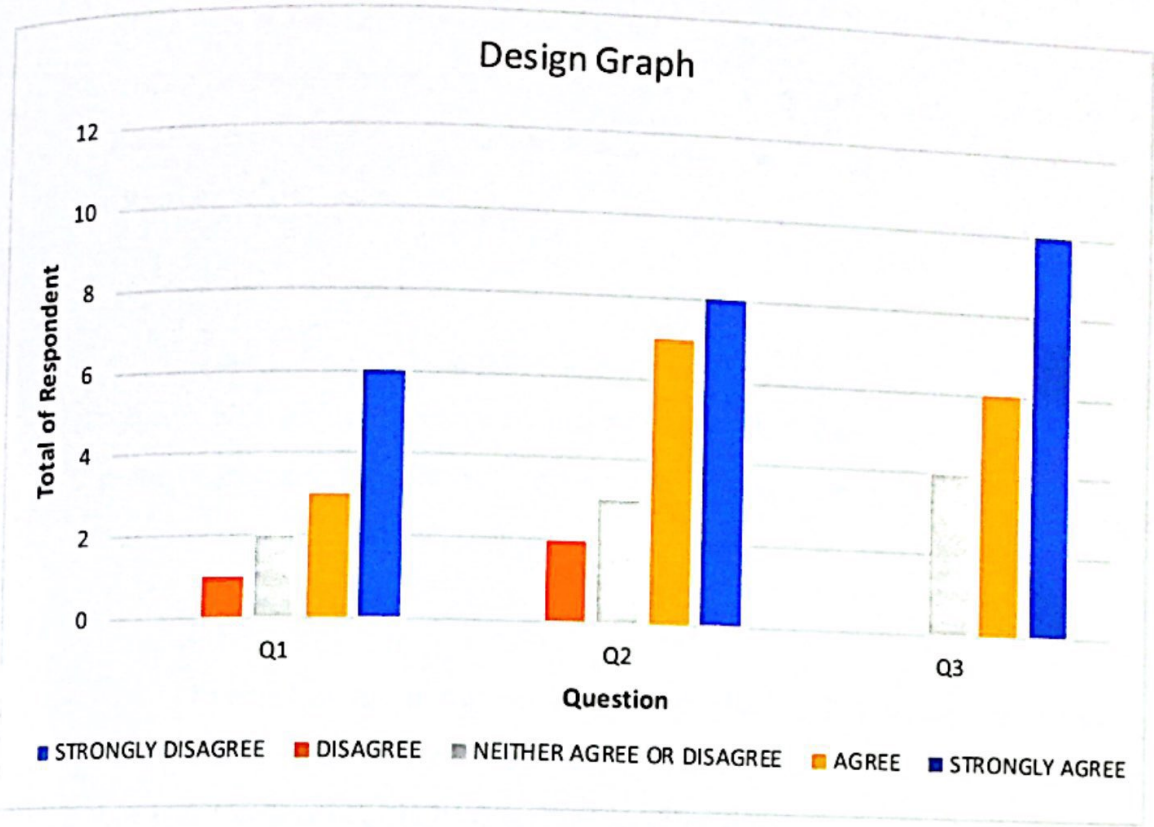


Figure 4.5: Design Graph

Table 4.3: Meaning of Design Bar Graph

Q1	the design is suitable to be use in everywhere
Q2	the design is light in weight
Q3	the design is easily to be carried

The figure 4.5 shows the data of design which is collected through data collection on muscle pain therapy device. From this product, there are three parts of questions. From the 20 subjects, there were 10 subject strongly agreed that the invention of the device is suitable use in everywhere, meanwhile there were 6 subjects slightly agreed with it. 3 subjects are neutral and 1 subject disagree that the design is suitable uses everywhere.

After that, there were 8 of the subjects strongly agree that the design is reliable in healing muscle pain, and 7 subject were also slightly agree with it. Besides, there were only 3 subject neither agree nor disagree, and only 2 subject disagree with the statement.

Lastly, the design is portable were strongly agreed by 10 subjects, and 6 subjects also slightly agree with the statement. And there were only 4 subjects neither agree nor disagree with the statement, and none of the subject disagree that.

In conclusion, as we can see through the graph whereby this device is suitable used at everywhere and the outcome of this experiment is positive where this device help in healing muscle. This device is easy to bring anywhere because of it design which is portable.

4.3.2 Comfortableness

The data of comfortability about the developed devices was takes. Four questions are consisted in this part, below is the table of the comfortability of Muscle Pain Therapy (MPT).

Table 4.4: Data of Comfortableness

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
I was found this Muscle Pain Therapy is easy to use and friendly.	0	1	4	4	11
MPT was modified from the original and has been change permanent to portable device, the design is suitable and comfortable.	0	2	2	4	12
During therapy session, the position of MPT is consistence while the place injury.	0	0	4	6	10
During therapy session, bright of led while near to skin and skin not heat	0	0	4	7	9

According the table 4.5 above the data was generated a graph by using Microsoft Excel, and the graph has shown in the figure 4.6 below.

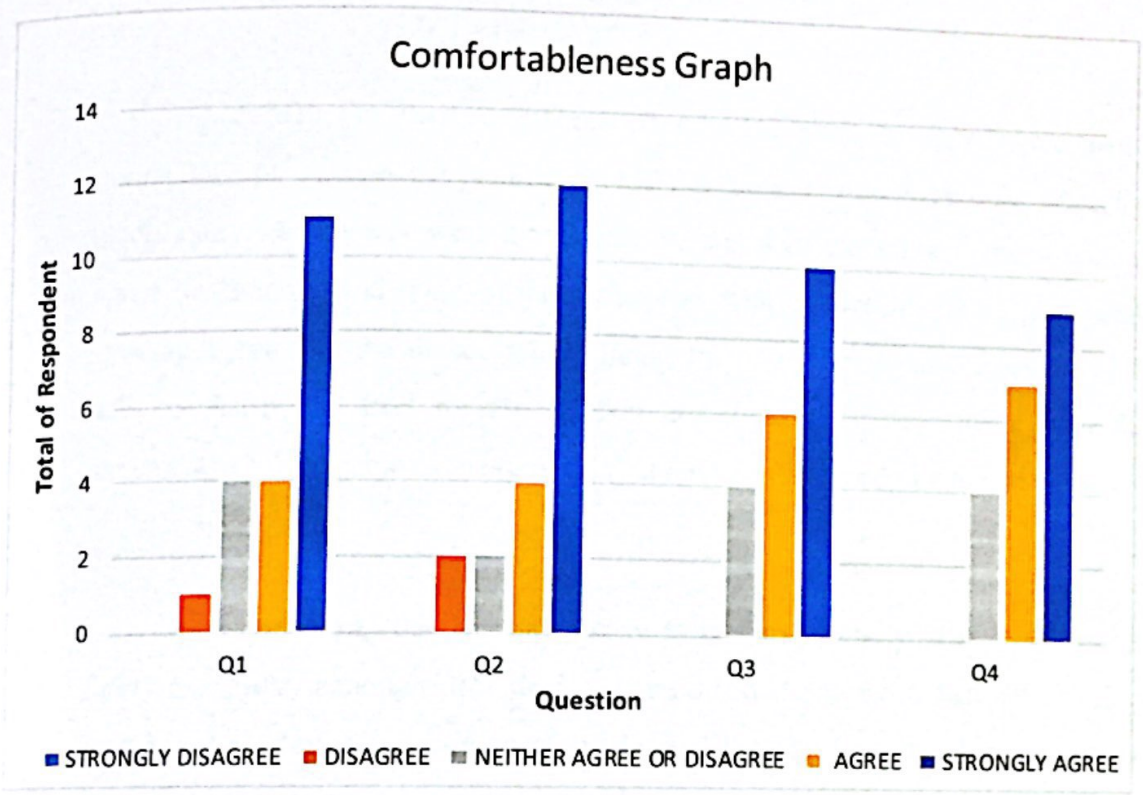


Figure 4.6: Comfortableness Graph

Table 4.5: Meaning of Comfortableness Bar Graph

Q1	I was found this Muscle Pain Therapy is easy to use and friendly.
Q2	MPT was modified from the original and has been change permanent to portable device, the design is suitable and comfortable.
Q3	During therapy session, the position of MPT is consistence while the place injury.
Q4	During therapy session, bright of led while near to skin and skin not heat

From the figure 4.6, 11 subjects are strongly agree that this muscle pain therapy is easy to use, 4 subjects are agree with that, 4 subjects are neither agree or disagree and only 1 subject is disagree with it. After that, 12 subjects were strongly agree that MPT was modified from the original and has been changed

from permanent to portable device, the design is suitable and comfortable, 4 subjects just agree with it, 2 subject neither agree and disagree and only 2 subject was disagreed.

According to third question, 10 subjects were strongly agree when during therapy session the position of MPT is static to one point only while the place injury, 6 subjects were agree with it, and 4 of the subjects were neither agree or disagree and none of them disagree with it. Besides, 9 subjects were strongly agree that the device when during therapy session, brightness of LED will not harm and lead to side of skin and 7 subjects were agree with the statement. Only 4 subjects were neither agreed or disagreed for this statement.

In conclusion, this device is easy to use and friendly due to its design functions. Next, although this design is modified from the actual design, this new invented device is more comfortable and the also very suitable for person experiencing muscles injury. then, this device is static during the therapy session and this will increase the effectiveness of healing of subject and the LED will not harm and not lead to skin damage because of the heat which is not produce much heat.

4.3.3 Effectiveness

The data of effectiveness about the developed devices was takes. Five questions are consisted in this part, below is the table of the effectiveness of Muscle Pain Therapy (MPT).

Table 4.6: Data of Effectiveness

	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Slightly Agree	Strongly Agree
I think that I would like to use this product frequently.	0	0	3	5	12
I think that I would need support of an injury person to be able to use this product.	0	1	4	7	8
I found that some additional functions in the product were well integrated	0	0	4	6	10
I imagine that most people would learn to use this product very quickly.	0	0	3	8	9
I think that product can be heal the muscle injury.	0	3	5	4	8

According the table 4.5 above the data was generated a graph by using Microsoft Excel, and the graph has shown in the figure 4.6 below.

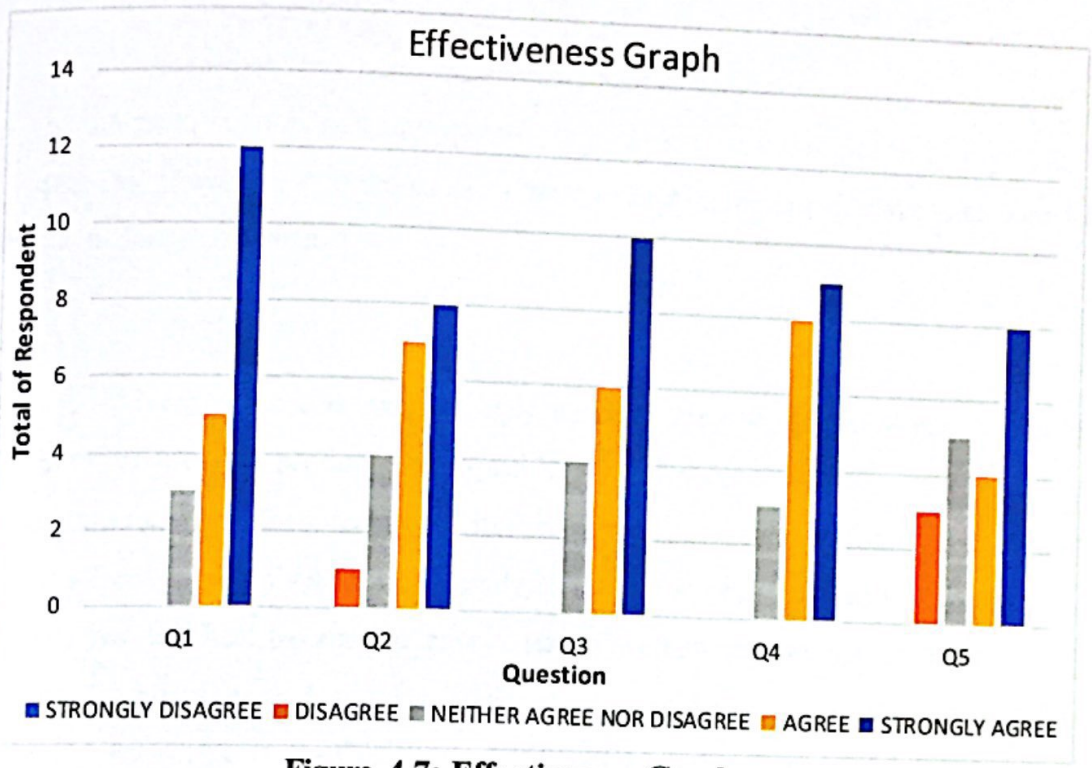


Figure 4.7: Effectiveness Graph

Table 4.7: Meaning of Effectiveness Bar Graph

Q1	I think that I would like to use this product frequently.
Q2	I think that I would need support of an injury person to be able to use this product.
Q3	I found that some additional functions in the product were well integrated.
Q4	I imagine that most people would learn to use this product very quickly.
Q5	I think that product can be heal the muscle injury.

From the figure 4.7, 12 subjects are strongly agree that this product are marketable and use this product frequently, 5 subjects are agree with that, and only 3 subject is neither agreeing or disagree with it. After that, 8 subjects were strongly agree when they think that I would need support injury person to be

able to use this product, 7 subjects agree with it. 4 subject neither agree or disagree for this statement and only 1 subject was disagree.

According the third question, 10 subjects were strongly agree that I would need support of injury person to be able to use this product., 6 subjects were agree with it, 4 of the subjects were neither agree nor disagree and none of them disagree with it.

Next, 9 subjects were strongly agreed I imagine that most people would learn to use this product very quickly, and 8 subjects were agreed with the statement. Then, 3 subjects were neither agreed nor disagreed with the statement of effectiveness of this device. Lastly, 8 subject strongly agreed that the product whether can heal the muscle injury, where we can see through the graph, there are 4 subjects agreed and 5 subjects slightly neither agree or disagree for this statement. but only 3 of the subjects are not agreed with the statement.

In conclusion, the frequency of usage of this product is high among subjects is high. Next, the support of injured person is needed in order to able to use this product. Furthermore, there are a few functions that can be made upgrade to this device to improve in future. since this device is easy to use, people will learn faster regarding use this device. Lastly, majorities agree that this product can heal muscle injuries.

4.4 Calculation of Healing Data

All data collected from Feedback Foam of Muscle Pain Therapy Treatment. Then, the calculation of healing data from first week occur by Result from first day, second day, third day, fourth day, fifth day, sixth day and seventh day divide to seventh day. Therefore, the data gets from average of healing percentage from seventh days.

Table 4.8, 4.9 and 4.10 showed result percentage of healing from first day to seventh day for first week until third week. This result gets from three subject is Akmal, Naim and Junaidi. Furthermore, it just takes a result from last session duration treatment of subject from first day. It has increases of healing data from first week to third week. The method to calculate the data is get the total of healing then divide to seven. The method that used to get the answer is mean operation of mathematical. Therefore, the data get from average healing data from week 1 until week 2.

Table 4.8: Healing data of Akmal

Week 1		Week 2		Week 3	
Day	Healing (%)	Day	Healing (%)	Day	Healing (%)
1	5	1	19	1	36
2	6	2	21	2	37
3	8	3	23	3	38
4	12	4	25	4	40
5	13	5	29	5	42
6	15	6	33	6	44
7	16	7	35	7	45
Total average (5+6+8+12+13+15+16) ÷7 =11%		Total average (19+21+23+25+29+33+35) ÷7 =26%		Total average (36+37+38+40+42+44+45) ÷7 =40%	

Table 4.9: Healing Data of Naim

Week 1		Week 2		Week 3	
Day	Healing (%)	Day	Healing (%)	Day	Healing (%)
1	6	1	18	1	33
2	7	2	22	2	35
3	9	3	23	3	37
4	11	4	24	4	38
5	13	5	27	5	39
6	14	6	29	6	42
7	17	7	32	7	44
Total average (6+7+9+11+13+14+17) ÷7 =11%		Total average (18+22+23+24+27+29+32) ÷7 =25%		Total average (33+35+37+38+39+42+44) ÷7 =38%	

Table 4.10: Healing Data of Junaidi

Week 1		Week 2		Week 3	
Day	Healing (%)	Day	Healing (%)	Day	Healing (%)
1	4	1	19	1	36
2	9	2	23	2	38
3	11	3	24	3	40
4	13	4	27	4	41
5	14	5	29	5	43
6	17	6	31	6	44
7	18	7	34	7	46
Total average (4+9+11+13+14+17+18) ÷7 =12%		Total average (19+23+24+27+29+31+34)÷7 =27%		Total average (36+38+40+41+43+44+46)÷7 =41%	

4.5 Healing Data

The data is derived from three subject which are sport player from Politeknik Sultan Salahuddin Abdul Aziz Shah. The student from Civil Engineering, Mechanical Engineering and Electrical Engineering. This data is collected from three subjects that injury at knee section. Subject are sport players from Polytechnic Sultan Salahuddin Abdul Aziz Shah. The subjects have different injury. First subject is Akmal have tissue torn at Lateral Collateral Ligament (LCL) section. Second subject is Naim has medium tissue torn at Anterior Cruciate Ligament (ACL) section. Then, for the last subject is Junaidi has injury at Medial Collateral Ligament (MCL) section. He gets tissue torn injury. After that, the data gets from result feedback foam after finish our treatment. Feedback foam show range of percentage from 1% to 100%. However, they need to fill in the feedback form that has been given after finish the treatment. In addition, the results of the feedback form will be calculated according to the average duration of a percentage within a week. Example, result data subject of Akmal is 10% get from total average by all treatment that has been done during 1 week. Data from feedback foam, just ticks until finish for four session of treatment per day. So, the data collection gets from 1 week by 1week.

The table 4.8, table 4.9 and table 4.10 shows result of healing data, which consists of 3 subject that the result is collected since three weeks. The outcome from doing treatment for these subject which is conducted for three weeks show positive regarding healing process.

Table 4.8 shows the data who are Akmal, Naim and Junaidi conducting for 4 times per day and from that treatment, the level of healing for Akmal and Naim get 11% meanwhile Junaidi get the highest percentage among others which 12% for first week treatment.

Table 4.11: Result Week 1

	Level of light	Time duration	Duration treatment	Level healing
Akmal	All LED on	20min	4 time/ 1day	11%
Naim	All LED on	20min	4 time/ 1day	11%
Junaidi	All LED on	20min	4 time/ 1day	12%

Table 4.9 above shows for second week for conducting the treatment, the result increased. The percentage of healing process for Akmal is 26%, Naim is 25% and for Junaidi is 27% for first week treatment.

Table 4.12: Result Week 2

	Level of light	Time duration	Duration treatment	Level healing
Akmal	All led on	20min	4 time/ 1day	26%
Naim	All led on	20min	4 time/ 1day	25%
Junaidi	All led on	20min	4 time/ 1day	27%

Table 4.10 above shows for third week when doing the treatment, the result increase positively. The percentage of healing for Akmal is 40%, Naim is 38% and Junaidi is 41% for first week treatment. This data is derived from three subjects.

Table 4.13: Result Week 3

	Level of light	Time duration	Duration treatment	Level healing
Akmal	All led on	20min	4 time/ 1day	40%
Naim	All led on	20min	4 time/ 1day	38%
Junaidi	All led on	20min	4 time/ 1day	41%

Figure 4.8 below show graph healing from three subject from sport player that take treatment from Muscle Pain Therapy Device.

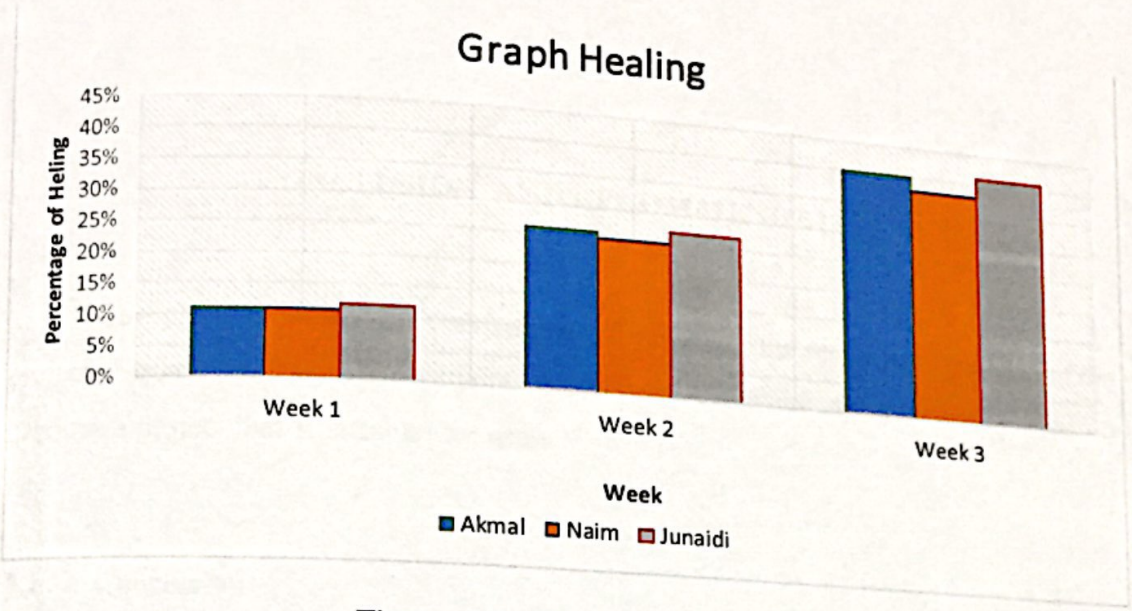


Figure 4.8: Healing Graph Bar

From figure 4.8 that shows result from 3 subject of three weeks by bar chart graph. This subject gets the treatment by muscle pain therapy device and take 20 minutes from the operation treatment start. Treatment focus to knee and injuries. the percentage of Akmal for week 1 is 11%, week 2 is 26% and week 3 is 40 %. Then for second subject, Naim achieved 11% for the first week. meanwhile 25% for second week and lastly 38% for week 3. After that, for Junaidi, the percentage is 12% for first week,27% for second week and he gets 41% for third week.

In conclusion, based on the experiment that has been conducted start from week 1 till week 3, subject experiences changes in positive way where the healing process increases. Hence, it is proven that injuries can be healed through this device among sport player.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

This chapter discuss the conclusions of the study, the results and analysis of the project. Suggestions for improvement projects in the future were also discussed to produce a project that is suitable for users.

5.1 Conclusion

As a conclusion, the Muscle Pain Therapy Device (MTP) is developed, and it have achieved the objective, which the primary objective is to develop muscle pain therapy to recovery injury of sport player.

The first objective showed this tool is well-crafted. Additionally, this tool has several levels to be produced well because when installing some wire from LED to IC board it has a bit of a problem. However, after a series of checks on the wire jumper, it has been repaired and the LED is back to normal. Therefore, the main objectives for this project are well achieved.

After that, the second objective which is to ease the patient and physiotherapist to carry and uses the devices. It can be proven through a successful post-questionnaire post survey on 20 subjects with sport injury problems. Data taken from these 20 subjects received a positive response to this generated device. In addition, this questionnaire is

divided into 3 sections, namely comfortability, effectiveness and design of device. Therefore, the data obtained can prove that this second objective is achieved.

Furthermore, the third objective is to analyze the effectiveness of muscle pain therapy for sport injury is archived. Then, data taken from the healing process proves the effectiveness of this tool for use in patients. Analysis data taken from 3 subjects proves that the injured sports player gradually recovered in performing frequent treatment using this tool. Therefore, the resulting project achieves the objectives as described in chapter 1.

5.2 Recommendation

Recommendation of the Biomedical Technician, KPJ Ipoh Specialist Hospital give recommendation to make this design smaller and combination holder and button together. Then, add LED laser to make faster for process treatment to heal the muscle injuries. Besides that, there is some recommendation from the 20 subjects, which the common comment of the device is the device too slow for healing process. Then, this problem will be solved for the future research or study.

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APPENDIX A: - PROGRAMMING

```
#include <LiquidCrystal.h>
LiquidCrystal lcd(7, 6, 5, 4, 3, 2);
int LED[] = {22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 53, 51, 49,
47, 45, 43, 41, 39, 37, 35, 33, 31};
const int gobtn = 19;
const int stopbtn = 20;
const int UpButton = 18;
const int DownButton = 17;
const int try3 = 14;
const int try2 = 15;
const int try1 = 16;
int UpStatus = 0;
int UpStatusLast = 0;
int DownStatus = 0;
int DownStatusLast = 0;
int SelectStatus = 0;
int SelectStatusLast = 0;
int Button1Status = 0;
int Button1StatusLast = 0;
int Button2Status = 0;
int Button2StatusLast = 0;
int counter = 0;

int minutes = 0;
int seconds = 0;

int time1 = 0;
int z = -1;
char time1_flag = 0;

void setup() {
 Serial.begin(9600);
 pinMode(gobtn, INPUT);
 pinMode(stopbtn, INPUT);
 pinMode(UpButton, INPUT);
 pinMode(DownButton, INPUT);
 pinMode(try1, INPUT);
 pinMode(try2, INPUT);
 pinMode(try3, INPUT);
 for (int num = 0; num < 30; num++) {
  pinMode(LED[num], OUTPUT);
 }
 lcd.begin(16, 2);
 lcd.setCursor(2, 0);
 lcd.print("  Laser");
 lcd.setCursor(0, 1);
 lcd.print("  Theraphy");
```

```
  delay(2500);
  lcd.clear();

  for (int x = 0; x < 30; x++) {
   digitalWrite(LED[x], LOW);
  } delay(500);

  //Pattern 2
  //      for (int y = 12; y < 16; y++) {
  //       digitalWrite(LED[y], HIGH);


  //Pattern 3
  //      for (int y = 0; y < 12; y++) {
  //       digitalWrite(LED[y], HIGH);
  //
  //    }


}

void Time_Minutes() {

 lcd.setCursor(0, 0);
 lcd.print("Timer:");
 lcd.setCursor(10, 0);
 lcd.print("min");

 UpStatus = digitalRead(UpButton);
 if (UpStatus != UpStatusLast) {
  if (UpStatus == HIGH)
  {
   time1 = time1 + 5;
   lcd.setCursor(7, 0);
   lcd.print(time1);
   lcd.print(" ");
  }
  delay(50);
}

DownStatus = digitalRead(DownButton);
if (DownStatus != DownStatusLast) {
 if (DownStatus == HIGH)
 {
  time1 = time1 - 5;
  lcd.setCursor(7, 0);
  lcd.print(time1);
  lcd.print(" ");
}
```

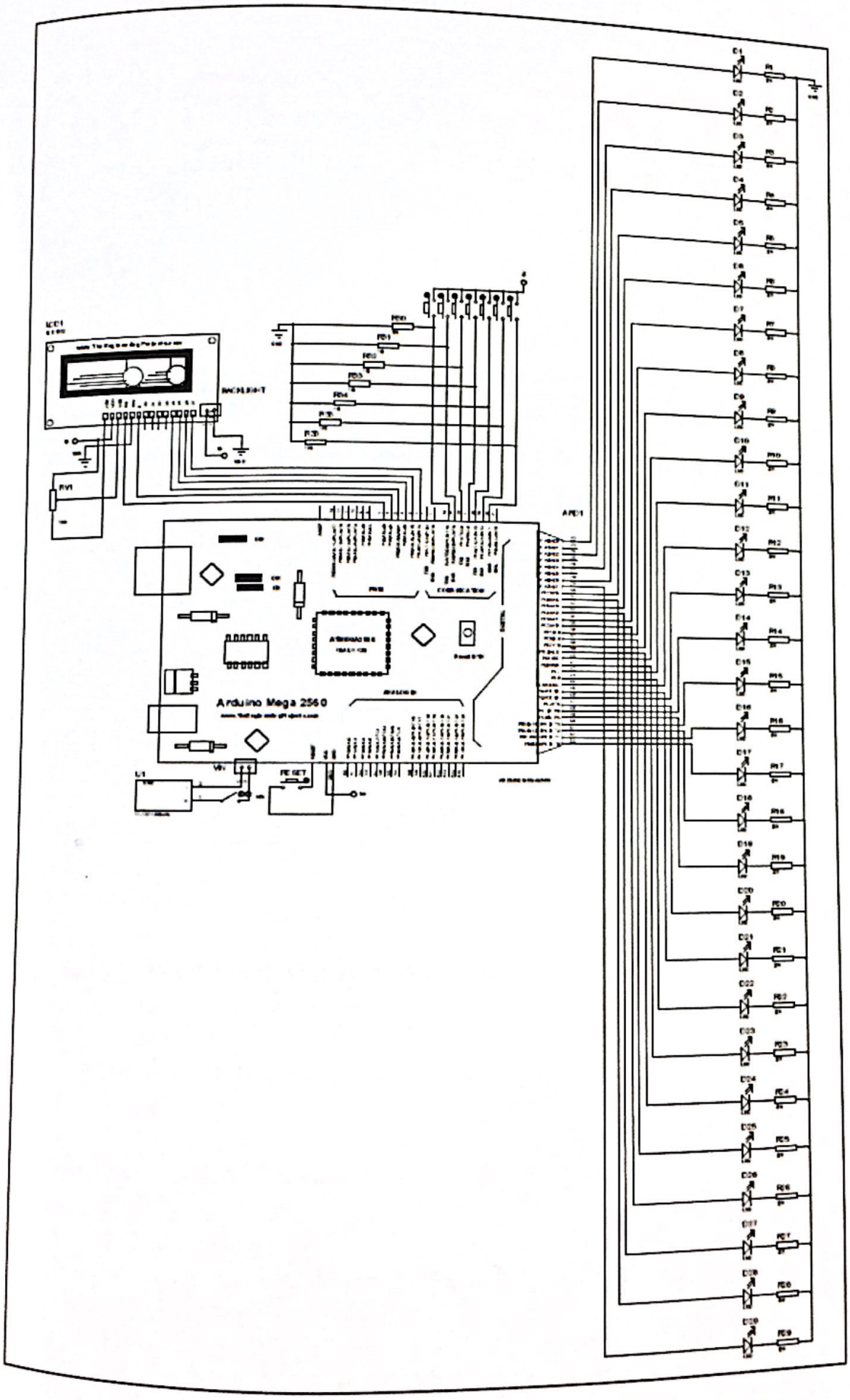
```
  delay(50);
 }


 if (time1 >= 30) {
  time1 = 30;
  lcd.setCursor(7, 0);
  lcd.print(time1);
  lcd.print(" ");
 }

 else if (time1 <= 0) {
  time1 = 0;
  lcd.setCursor(7, 0);
  lcd.print(time1);
  lcd.print(" ");

 }
 UpStatusLast = UpStatus;
 DownStatusLast = DownStatus;

 if (digitalRead(gobtn)) {
  lcd.clear();
  lcd.print("      START");
  delay(2000);
  lcd.clear();
  time1_flag = 1;
  z = 1;
 }
}

void loop() {
 Time_Minutes();

 if (digitalRead(try1)) {
  for (int y = 0; y < 29; y++) {
   digitalWrite(LED[y], LOW);
  }
  for (int y = 16; y < 29; y++) {
   digitalWrite(LED[y], HIGH);
  }
 }


 if (digitalRead(try2)) {
  for (int y = 0; y < 29; y++) {
   digitalWrite(LED[y], LOW);
  }
  for (int y = 12; y < 29; y++) {
   digitalWrite(LED[y], HIGH);
```

```
  }
  digitalWrite(LED[8], HIGH);
 }

 if (digitalRead(try3)) {
  for (int y = 0; y < 29; y++) {
   digitalWrite(LED[y], LOW);
  }
  for (int y = 0; y < 29; y++) {
   digitalWrite(LED[y], HIGH);
  }
 }

 while (z == 1) {
  minutes = time1;
  while (time1_flag) {
   lcd.setCursor(5, 0);
   (minutes < 10) ? lcd.print("0") : NULL;
   lcd.print(minutes);
   lcd.print(":");
   (seconds < 10) ? lcd.print("0") : NULL;
   lcd.print(seconds);
   lcd.display();
   stepDown1();
   delay(1000);

   //Others
   if (digitalRead(try1)) {
    for (int y = 0; y < 29; y++) {
     digitalWrite(LED[y], LOW);
    }
    lcd.setCursor(5, 0);
    (minutes < 10) ? lcd.print("0") : NULL;
    lcd.print(minutes);
    lcd.print(":");
    (seconds < 10) ? lcd.print("0") : NULL;
    lcd.print(seconds);
    lcd.display();
    stepDown1();
    delay(1000);
    for (int y = 16; y < 29; y++) {
     digitalWrite(LED[y], HIGH);
    }
   }

  //Laser
  else if (digitalRead(try2)) {
   for (int y = 0; y < 29; y++) {
    digitalWrite(LED[y], LOW);
```

```
    }
    lcd.setCursor(5, 0);
    (minutes < 10) ? lcd.print("0") : NULL;
    lcd.print(minutes);
    lcd.print(":");
    (seconds < 10) ? lcd.print("0") : NULL;
    lcd.print(seconds);
    lcd.display();
    stepDown1();
    delay(1000);
    for (int y = 12; y < 29; y++) {
     digitalWrite(LED[y], HIGH);
    }
    digitalWrite(LED[8], HIGH);
   }

   //Centre
   else if (digitalRead(try3)) {
    for (int y = 0; y < 29; y++) {
     digitalWrite(LED[y], LOW);
    }
    lcd.setCursor(5, 0);
    (minutes < 10) ? lcd.print("0") : NULL;
    lcd.print(minutes);
    lcd.print(":");
    (seconds < 10) ? lcd.print("0") : NULL;
    lcd.print(seconds);
    lcd.display();
    stepDown1();
    delay(1000);
    for (int y = 0; y < 29; y++) {
     digitalWrite(LED[y], HIGH);
    }
   }

   if (digitalRead(stopbtn)) {
    lcd.setCursor(5, 1);
    lcd.print("PAUSE");
    time1_flag = 2;
    while (time1_flag) {
     if (digitalRead(gobtn)) {
      lcd.clear();
      time1_flag = 1;
      break;
     }
    }
   }
  }
 }
```

```
}

void stepDown1() {
 if (seconds > 0) {
  seconds -= 1;
 } else {
  if (minutes > 0) {
   seconds = 59;
   minutes -= 1;
  } else {
   time1_flag = 0;
   for (int y = 0; y < 29; y++) {
    digitalWrite(LED[y], LOW);
    time1 = 0;
   }
   standby();
  }
 }
}

void standby() {
 lcd.clear();
 lcd.setCursor(5, 0);
 lcd.print("DONE");
 delay(1500);
 lcd.clear();
 lcd.setCursor(0, 0);
 lcd.print("Press reset btn");
 lcd.setCursor(0, 1);
 lcd.print("to start");
}
```

APPENDIX B:- SCHEMATIC DIAGRAM



APPENDIX C:- QUESTIONNAIRE (Post-Survey)

POLITEKNIK
Jabatan Pengajian Politeknik

POLITEKNIK SULTAN SALAHUDDIN ABDUL AZIZ SHAH

Muscle Pain Therapy (MPT) Usability Form

Thank you for taking time to fill in this questionnaire, you will remain anonymous. The goal of this questionnaire is to get some data through the range of instrument usability about Muscle Pain Therapy. Please indicate the extent to which you choose with the following statements by putting a √ in the appropriate box by following the range.

Age :

Gender : F ☐ M ☐

Occupation: _____

1. Are you found this device is suitable to use?
   ( ) Yes
   ( ) No
2. Are you familiar with this device?
   ( ) Yes
   ( ) No
3. Do you understand the function of this device?
   ( ) Yes
   ( ) No
4. If this device in market, do you prefer to have it?
   ( ) Yes
   ( ) No
5. Is this device is suitable to use and help to muscle recovery
   ( ) Yes
   ( ) No

No	Item & Elements	Strongly agree	Agree	Neither agree or Disagree	Disagree	Strongly Disagree
1	**COMFORTABLENESS** a) I was found this Muscle Pain Therapy (MPT) is easy to use and friendly. b) MPT was modified from the original and has been change permanent to portable device, the design is suitable and comfortable. c) During therapy session, the position of MPT is consistence while the place injury. d) During therapy session, bright of led while near to skin and skin not heat.	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐
2	**DESIGN** a) The design is suitable to be use in everywhere. b) The design is give good effect to heal muscle pain c) The design is easily to be carried.	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐
3	**EFFECTIVENESS** a) I think that I would like to use this product frequently. b) I think that I would need support of an injury person to be able to use this product. c) I found that some additional functions in the product were well integrated.	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐	☐ ☐ ☐ ☐

	d) I imagine that most people would learn to use this product very quickly.						
	e) I think that product can be heal the muscle injury.						

Other recommendation for the purpose to improve Muscle Pain Therapy:

APPENDIX D:- LETTER OF ACKNOWLEDGEMENT FROM KPJ IPOH

POLITEKNIK Sultan Salahuddin Abdul Aziz Shah

Feedback Foam of Muscle Pain Therapy Treatment

Name : _____

Age : _____

Type of injury : _____

Please putting (√) in the appropriate box by following the range of healing percentage after finish our treatment.

Percentage of Healing									
10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
1% ☐	1% ☐	1% ☐	1% ☐	1% ☐	1% ☐	1% ☐	1% ☐	1% ☐	1% ☐
2% ☐	2% ☐	2% ☐	2% ☐	2% ☐	2% ☐	2% ☐	2% ☐	2% ☐	2% ☐
3% ☐	3% ☐	3% ☐	3% ☐	3% ☐	3% ☐	3% ☐	3% ☐	3% ☐	3% ☐
4% ☐	4% ☐	4% ☐	4% ☐	4% ☐	4% ☐	4% ☐	4% ☐	4% ☐	4% ☐
5% ☐	5% ☐	5% ☐	5% ☐	5% ☐	5% ☐	5% ☐	5% ☐	5% ☐	5% ☐
6% ☐	6% ☐	6% ☐	6% ☐	6% ☐	6% ☐	6% ☐	6% ☐	6% ☐	6% ☐
7% ☐	7% ☐	7% ☐	7% ☐	7% ☐	7% ☐	7% ☐	7% ☐	7% ☐	7% ☐
8% ☐	8% ☐	8% ☐	8% ☐	8% ☐	8% ☐	8% ☐	8% ☐	8% ☐	8% ☐
9% ☐	9% ☐	9% ☐	9% ☐	9% ☐	9% ☐	9% ☐	9% ☐	9% ☐	9% ☐
10% ☐	10% ☐	10% ☐	10% ☐	10% ☐	10% ☐	10% ☐	10% ☐	10% ☐	10% ☐

a). Give your comment/ suggestion about your feedback after treatment.

THANK YOU FOR YOUR COOPERATION

APPENDIX E: - LETTER OF ACKNOWLEDGEMENT FROM KPJ IPOH

KPJ Ipoh Specialist Hospital,

Jalan Raja Di Hilir,

Tambun 30350 Ipoh,

Perak Darul Ridzuan

20 May 2017

Sir/Madam

Subject: Letter of Acknowledgement for " Muscle Pain Therapy"

Hereby with a sense of gratitude and appreciation for the innovation that has been made on the Muscle Pain Therapy. The innovator detail as below:

Name of innovator : Mohamad Abu Huzaifah Bin Aziz
NRIC : 940826-02-5379
Innovation's name : **Muscle Pain Therapy**

2. This innovation also demonstrated the physiotherapy device to provide for sport player. Furthermore, the innovation is suitable to market for the use by sport player.

3. We hope for more innovation to improve the quality of therapy in rehabilitation field.

Thank You

Sincerely,

AHMAD RASHIDI HAWARY
KPJ Ipoh Specialist Hospital
Bio-Med Technician
Tel: 05-2408777
Fax: 05-2437259

Name:

Date: 20/5/17