INTELLIGENT SLAB: WEARABLE DEVICES FOR PATIENT GAIT ANALYSIS WHILE WEARING PARA RUBBER SLAP

K.Noimanee[1], S.Noimanee[2] and N. La-oopugsin[3]

ABSTRACT

This paper presents the design of the patient's gait analysis who is wearable wearing Para rubber slap that is equipped with intelligent sensors, which the patient is at the Princess Maha Chakri Sirindhorn Medical Center (MSMC) in order to study the needs of patients that are comfortable to wearable the slap are made from rubber with an intelligent pressure and EMG analyzing of the patient's walking behavior at the hospital or own home. Which the gait analysis of the injured patients must be mentioned, which is useful for treatment as well because the doctor who treats the patient's information by observing the gait behavior. The Orthopedic Doctor is able to analyze the patient gait according to various wearable intelligent sensors. After the introduction of the gait process, the principles and characteristics of the wearable intelligent sensors used in gait analysis are provided. The analytical method of walking along the wearable intelligent sensor is divided into natural walking kinetics. An electrical mechanical leg walking which studies on current methods have been reviewed and applied in rehabilitation and clinical diagnosis in a separate summary with the development of sensor technology and analytical methods, walking analysis using wearable sensors is expected to play an increasingly important role in clinical.

Keywords: EMG sensors, Patient Gait, walking Analysis, Wearable sensors

1. INTRODUCTION

1.1 Para Rubber

Rubber is a perennial plant. Originated in the Amazon River Basin Brazil and Peru South America by the native people called "Kao Chuu" , meaning the tree weeping until the year 1770. Joseph Presley found that the rubber can be used to remove black marks of the pencil. Therefore called the eraser or rubber, which is a terminology used in England and the Netherlands only The center of cultivation and trading of rubber in South America, but originally in Para, Brazil. This type of rubber is therefore called rubber[1].

The rubber trees growing in the southern part of Thailand. Which has brought rubber to be manufactured into various products such as latex mattresses, rubber pillows and the research team has therefore used rubber to develop into such slab. Due to the economic situation in the first quarter of the year 2019, the world economy is quite slow, obviously, especially the Chinese economy that the manufacturing sector PMI at the beginning of the quarter.

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The ground-to-ground response has been developed and used in laboratories. However, this standard walking analysis requires movement only in the laboratory and the equipment is expensive and time-consuming to install the system. Each time the operation very long. In addition, there are limitations in terms of moving areas and walking cycles for patients/patients observed. To reduce these problems, the research team studied the alternative pathway analysis using intelligent sensors attached to the

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rubber splint. Which is inexpensive and he/she can be used outside the hospital as well[2].

1.1.1 Basis of human gait analysis.

Walking is considered a daily routine of mankind that needs to be treated while the body is perfect. Which will make the whole central nervous system of patient balanced and also stimulate other sensory systems to work effectively. While the human body is walking, the first phase (contact phase) touches one foot, pushing the floor, causing the reaction force to rise, sending the body forward, which the hips and thighs change from the posture. Bend into the most stretched position and strut the same foot from the ground. Later, the knees will terminology used in England and the Netherlands only The center of cultivation and trading of rubber in South America, but originally in Para, Brazil. This type of rubber is therefore called rubber[1].

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(1) (2) (3)

Figure 1. Gait steps in normal gait cycles in which the weight on the heel for the first time and the front foot before changing the feet.

In Figure 1. The number (1) explain initial contact: this step comprises the moment when the foot touches the floor for the first time. The joint postures presented at this time determine the limb's loading response pattern. The number (2) explain loading response: this step is the beginning put the weight on the first-floor contact and continue walking on the floor. The number (3) explain before leg changing: this step completes the single-limb support. The stance begins with the heel rising and continues until the other foot strikes the ground, in which the heel rises and the limb advance over the forefoot rocker. Throughout this step, bodyweight moves ahead of the forefoot. Each step of the walk is related to the movement of the body, such as the arms, legs, knees, joints, and segments. The weight of the foot to contact the floor will create confidence in human balance. This behavior of human combination of this step also enables the limb to accomplish three basic tasks, namely, weight acceptance, single-limb support, and limb advancement. Weight acceptance the stance period through the first contact the floor and loading response. Based on the analysis of the gait step and basic of limb movement, it may be detected effectively after orientations of the legs are accurately obtained.

1.2 Sensors for analysis in this research.

Gait analysis of a patient who wearing Para rubber slap in MSMC. We are used by two different types of motion sensors, such as the force sensors, and electromyography (EMG) sensors. The basic principles and features of these sensors and structure described in the following.

1.2.1 Force sensors

We will force sensors to be embedded into Para rubber slap to realize ambulatory measurements of the actual vector direction depending on the nature of the interface between the foot and the ground. A force sensor is a transducer which converts force into an electrical output value. Although there are many varieties of force sensors, strain gauge load cells are the most commonly used type. A force sensor is a transducer which converts force into an electrical output value. Although there are many kinds of force sensors, strain gauge force sensors are the most commonly used type.

1.2.1.1 Basic Methods of Force Measurement [6-8].

An unknown force maybe measured by the followings:

1. Balancing if against the known gravitational force on a standard mass, either directly or through the system of levers.
2. Measuring the acceleration of the body of known mass to witch the unknown force is applied.
3. Balancing it against a magnetic force developed by the interaction of a current-carrying coil and magnet.
4. Transducing the force to fluid pressure and then measuring the pressure.
5. Measuring the change precession of gyroscope caused by an applied torque related to the measured force.
6. Measuring the change in frequency of a wire tensioned by the force.

Method 1st

In Figure 2, method 1st is shown by the analytical balance, the pendulum scale, and the platform scale. The analytical balance, while simple in principle, requires careful design and operation to realize its maximum performance. The beam is designed so that the center of mass is only slightly below the knife-edge pivot and thus barely in stable equilibrium. This maker the beam deflection a very sensitive indicator of unbalance. For the low end of a particular instrument's range, often the beam deflection is used as the output reading later than attempting to null by adding masses or adjusting the arm length of a poise weight. The approach is faster than nulling but requires that the deflection angle unbalance relation be accurately known and stable. This relation tends to vary with the load on the balance, because of deformation of knife edges, etc., but the careful design can keep this to a minimum. Force highly accurate measurements the buoyant force due the immersion of standard mass in air have to be taken into account. Also, the most sensitive balances have to be installed in temperature controlled chambers and manipulated be remote control to reduce the effects of the operator's body heat and convection currents.

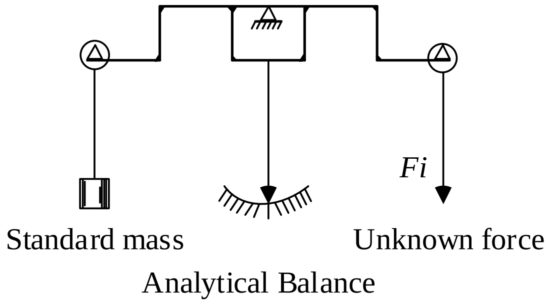

Figure 2. Basic force measurement method.

Typically, a temperature difference of 1/20°C between the two arms of balance can cause an arm-length ratio change of 1 ppm, significant in some applications. Commercially available analytical balances maybe classified as follow table 1:

Table 1. Commercially analytical balance.

Description	Range, g	Resolution, g
Macro analytical	200-1,000	10^{-4}
Semimicro analytical	50-100	10^{-5}
Micro analytical	10-20	10^{-6}
Micro balance	Less than 1	10^{-6}
Ultramicro balance	Less than 0.01	10^{-7}

The pendulum scale is a deflection type instrument in which the unknown force is converted to a torque that is then balanced by the torque of a fixed utilizes specially shaped sectors and steel tapes to linearize the inherently nonlinear torque angle relation of a pendulum. The unknown force F_i maybe applied directly as in Figure 3 or through a system of levers. And electrical signal proportional to force is easily obtained from any angular displacement transducer attached to measure the angle Θ_o.

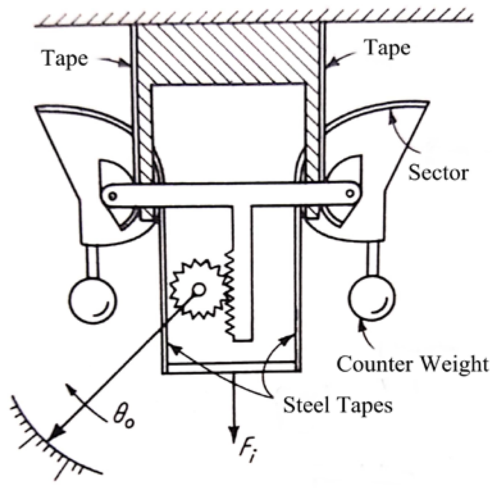

Figure 3. Pendulum Scale displaying. [6]

The platform scale utilizes a system of levers to allow measurement of large forces in terms of smaller standard weights. The beam is brought to null by a proper combination of pan weights and adjustment of poise weight lever arm along its calibrated scale. The scale can be made self-balance by adding and electrical displacement pickup for null detection and in amplifier motor system to position the poised weight to achieve null. Another interesting feature is that if a/b = c/d is shown in Figure 4, the reading of the scale is independent of the location of F_i on the platform. Since this is quite convenient, most commercial scales provide this feature by use of the suspension system shown or others that allow similar results.

Method 2nd

In Figure 5 the use of an accelerometer for force measurement is of somewhat limited application since the force determined is the resultant force on the mass. Often several unknown forces are acting, and they cannot be separately measured by this method.

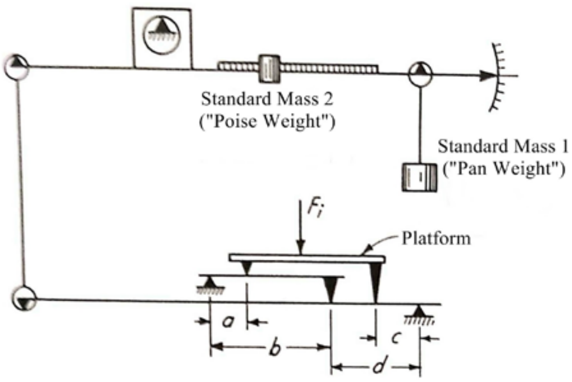

Figure 4. Platform Scale.

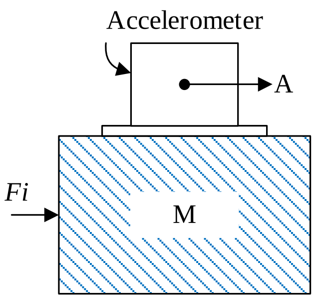

Figure 5. Force measurement using accelerometer.

Method 3rd

The electromagnetic balance utilizes a photoelectric (or another displacement sensor) null detector, an amplifier, and torquing coil in a servo system to balance the difference between the unknown force Fi and the gravity force on the standard mass. Its advantage relative mechanical balance is ease of use, less sensitive to the environment, faster response, smaller size, and ease of remote operation. Also, the electric output signal is convenient for continuous recording and/or automatic control application. Balances with built-in microprocessors arrow even convenience [9], versatility, and speed of use by automating routine procedures and providing feature not formerly feasible. Automatic tare- weight systems subtract container weight from the total weight to give net weight when the material is placed in the container. Statistical routines allow immediate calculation of mean and standard deviation for a series of weighing. Accurate weighing of live laboratory animals is facilitated by averaging scale readings over a preselected time. Interfacing the balance to printers for permanent recording also is caused by the microprocessor.

Method 4th

The method is shown in Figure 6 by hydraulic load cells are completely filled with oil and usually have a preload pressure of the order of 30 pounds/in2. Application of load increase the oil pressure, which is read on an accurate gauge. Electrical pressure sensors can be used to detect an electrical signal. Capacities to 100,000 pounds are available as standard while special units up to 10 million pounds are obtainable. Accuracy is of the order of 0.1% of full scale; the resolution is about 0.02%. A hydraulic totalizer is used to provide a single pressure equal to the sum of up to 10 individual pressures in multiple-cell systems used for tank weighing, etc., the pneumatic load cell shown in this Figure uses a nozzle-flapper transducer as a high-gain amplifier in a servo loop. This increase in pressure acting on the diaphragm to its former position. For any constant Fi, the system will come to equilibrium at a specific nozzle opening and corresponding pressure Po. The static behavior is given by the equation as following [6]:

$$(F_i - p_o A) K_d K_n \quad = \quad p_o \tag{1}$$

Where

K_d = diaphragm compliance, inch/lbf
K_n = nozzle-flapper gain, (lb/inc^2)/in

Solving for p_o, we get

$$p_o \quad = \quad \frac{F_i}{1/(K_d K_n) + A} \tag{2}$$

Now K_n is not a constant value, but varies somewhat with x, leading to a nonlinearity between x and p_O. Anyway, in practice, the variable of $K_d K_n$ are very large, so that the value of 1/(KdKn) is made negligible compared with A, which gives which is linear A is constant.

$$p_o \quad = \quad \frac{F_i}{A} \tag{3}$$

As is any feedback system, dynamic instability limits the amount of gain that actually can be used. A typical supply pressure ps is 60lb/in2, and since the maximum value of po cannot access ps this limits Fi to somewhat less than 60A.

Method 5th

This method is widely used to both static and dynamic loads of frequency content up to many thousand hertz. While all are essentially spring-mass systems with damping, they differ mainly in the geometric form of “spring materials” and in the displacement sensors used to detect an electrical signal. The displacement sensed maybe a gross motion, or strain gages maybe judiciously located to sense force in terms of strain. As an example, the parallelogram flexure of Figure 9 is extremely rigid to all applied forces and moments except in the direction display by the arrow. A displacement transducer arranged to measure motion in the sensitive direction thus to measure only that component of an applied vector force which lies along the sensitive axis. Anyway, the action of this flexure may be most easily visualized by considering it as a four-bar linkage with flexure hinges at the thin sections a, b, c, and d.

Because of the importance of elastic force sensors in modern dynamic measurements, we devote a considerable portion of this paper to their consideration. Although they may differ widely in detail of construction, their dynamic response form is generally the same, and so we treat an idealized model representative of all such sensors in the next chapter.

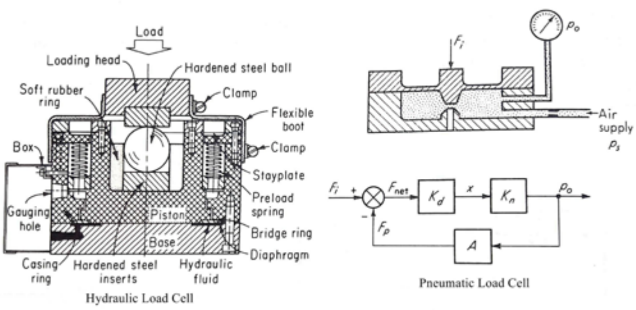

Figure 6. Extremely rigid to all applied forces.

1.2.1.2 Characteristics of Elastic Force Sensors [7-8].

Figure 7 shows an idealized model of an elastic force. The relationship between the input force and output displacement is easily established as a simple second-order form:

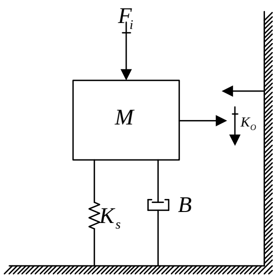

Figure 7. Elastic force sensor.

$$F_i - K_s x_o - B\dot{x}_o = M\ddot{x}_o \tag{4}$$

$$\frac{x_o}{F_i}(D) = \frac{K}{D^2/\omega_n^2 + 2\xi D/\omega_n + 1} \tag{5}$$

Where
$$\omega_n = \sqrt{\frac{K_s}{M}} \tag{6}$$

$$\xi = \frac{B}{2\sqrt{K_s M}} \tag{7}$$

$$K = \frac{1}{K_s} \tag{8}$$

Note that devices of this type are also accelerometers and produce a spurious output in response to base vibration inputs. For sensors that do not measure a gross displacement but rather use strain gages bounded to “spring” Ks, the output strain $\in$ may be substituted for x_o if K_s is reinterpreted a force/unit strain rather than force/unit deflection. In many sensors, a distinct and separate “spring” and “mas” cannot be distinguished because the elasticity and inertia are distributed later than lumped. In these cases, for design purposes, the natural frequency has to calculate from the approximate formulas [8] for the geometric shapes involved rather than by employing equation (6). Once the sensor is constructed, its lowest natural frequency generally can be found experimentally, as can ξ, which is usually small and difficult to calculate since B usually represent parasitic friction effects. Generally, the sensitivity of K is available theoretically from strength-of-materials or elasticity formulas, whether it relates to a gross deflection or a local unit strain. Once the sensor is constructed, it should be given an overall calibration relating electrical output to force input since none of the theoretical formulas is sufficiently accurate for this purpose. In this research we use of four sensors are force sensor and EMG sensor as shown in Figure 8 and 9 the force module sensors with Arduino microcontroller is used in this research.

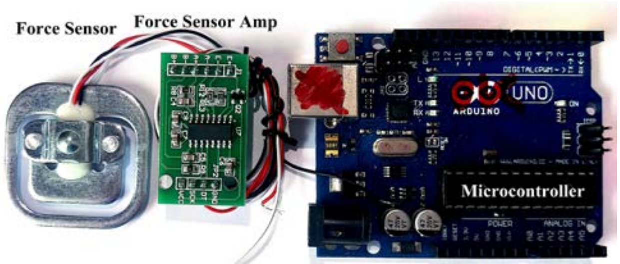

Figure 8. Force module sensors with the microcontroller unit.

1.2.2 Sensors of Electromyography (EMG)

In the analysis of walking, we can observe leg muscle changes by measuring EMG. To measure the behavior of human muscles in the lower legs in walking, the electromyography (EMG) was developed to perform an indirect measurement of muscle activity using 3 surface electrodes. That electrodes can pick-up voltage potentials from patient muscle to provide small voltage on the timing and intensity of muscle contraction, as shown in Figure 9.

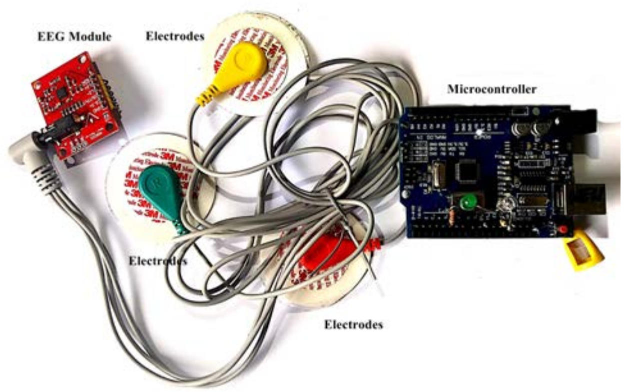

Figure 9. EMG module sensors with the three electrodes and Arduino microcontroller unit.

2. STRUCTURE OF PARA RUBBER SLAP

2.1 Para rubber slap

Latex is a polymer material that originates from the liquids of some plants. Which looks like a milky white liquid with colloidal properties. Small particles have water media. Therefore Para rubber slap made from the latex of the rubber tree is a polymer material that originates from the liquid of the rubber tree which is a milky white-like liquid, has a colloidal property, a small particle with water media. Which the world's largest latex producer is Southeast Asia represents 90% of the total production. The rest comes from Central Africa. Which rubber varieties produced in Southeast Asia is Hevea brasiliensis Latex from the tree is called field latex.

The latex obtained from the rubber tree is a small rubber granule scattered in the water (emulsion). It is a white liquid. It has a colloidal condition with a solid content of about 30-40% and a pH of 6.5 – 7. The latex has a density of 0.975-0.980 g/mm. And it has a viscosity of 12-15 centipoise which the components in the latex are divided into 2 parts: the first part is the 35% is rubber part, and second part is 65% of non-rubber, which has 55% water content and 10% lutoid. Fresh rubber that can be tapped from the rubber tree will maintain the latex's condition for not more than 6 hours.

The latex that can be tapped from the rubber tree will remain in the water for not more than 6 hours due to bacteria in the air and from the shell of the rubber tree. Such as proteins, sugar, phospholipids, which bacteria will grow rapidly, the reaction that occurs after the bacteria eats nutrients is that they are decomposed into various types of gases such as carbon dioxide gas. Methane gases begin to rot and become smelly.

Increasing volatile acidity in latex will result in decreased pH of latex. Therefore, the latex is lost, the condition observed from the latex will gradually become viscous, because the rubber particles begin to grind and become larger. Until the latex loses its condition, the latex is separated into two parts: the rubber part and the serum part [3]. Therefore, in order to prevent the loss of the condition of the latex, so that the particles of rubber granules occur naturally together, the chemicals are put into the latex to keep the latex to remain liquid.

The chemical used in the storage of latex is called Anti-capture agent (Anticoagulant), including ammonia, sodium sulfide Formaldehyde, etc., in order to keep the latex from losing the condition. There are two types of natural rubber that are used: latex pattern and dry rubber pattern. In the form of latex, fresh latex is then separated to increase the concentration of the rubber, one step ahead with various methods, but commonly used in the industry is the use of centrifuge machines. While the preparation of dry rubber is often used to put acetic acid into fresh latex. The dilution of acetic acid into the latex causing the latex to clump and the separation between the rubber and water. The water that is contaminated in the rubber is removed by rolling with two rollers. The main method to completely dry the rubber is in two methods: the first method is rubber fumigation and the second method is crepe rubber production, but because the rubber is produced from farmers from different sources Causing the need to classify the rubber according to the purity of the tire.

Research team, especially Assoc.Prof. Niyom Laopakon, MD. He is a lecturer in the Department of Orthopedics Faculty of Medicine, Srinakharinwirot University. By focusing on users with accidents stroke paralysis at present, the number has increased, especially for elderly people who need close care. Therefore able to respond in terms of ease of wearing, strong, durable than general cast plaster made from plaster and the important thing is inexpensive, average 200 baht/side. While the original Para rubber slap made from plaster for 400-500 baht per side are both broken and not waterproof. The research team also developed a soft splint from rubber for use with fracture patients. Soft slap for fracture patients progress about 90%, both being contacted by entrepreneurs interested in bringing to the commercial level because it is a device that meets the needs of a large market. Investment and importantly can reduce the cost of patients. From the original cost of changing the splint 1,000 baht per times and having to change three times. This invention is usable throughout life and has a size to choose from, like shoes and designed in colorful patterns. In the future, plans to develop arm and neck slap as an alternative to consumers.

In making para rubber slaps, starting from preparing material from plaster by measuring the size of the patient's legs, as shown in Figure 10, when it has been molded, then it is printed with two layers of structure: such as external structure and internal structure as shown in Figure 11. The external structure uses natural rubber, a solid type sheet, which has properties that emphasize the strength that can support the weight and also color as needed.

Figure 10. Measuring size legs of each patient and preparation of rubber crucible and casting prototype.

(a) (b)

Figure 11. The external and internal structure of the Para rubber slap

In Figure 11 (a) is an external structure and (b) the interior is designed to be convenient to wear and has softness properties in contact with the skin of the patient, as well as good ventilation and easy to clean. Compared to plastic plaster or slap which are expensive and have environmental problems due to difficult degradation. But Para rubber slaps can be used at a low cost and the patient can take care easily, and there is no problem with the environment because it is easy to digest in the medical field, it is easy to remove the splint from the patient's legs.

The prototype of Para rubber slap is shown in Figure 12 and Figure 13 that are ready to use but has not yet designed an intelligent sensor installation, which the research team is currently in progress.

Figure 12. The internal structure of Para rubber slaps developed complete, ready to use

Figure 13. The Para rubber slaps that are used with volunteer patient in MSMC hospital

2.2 The design of installation of sensor position in Para rubber slap.

2.2.1 Installation of force sensor

In Figure 14 as shows a block diagram of the force sensor design and electrical muscle signals measure force and electromyography (EMG), which consists of force sensors, force mixer with pre-amp and electromyography modules used in this research. We will embed the sensors in the position of the heel and soles of the front of the patient in 4 sensors, as shown in Figure 15 and Figure 16.

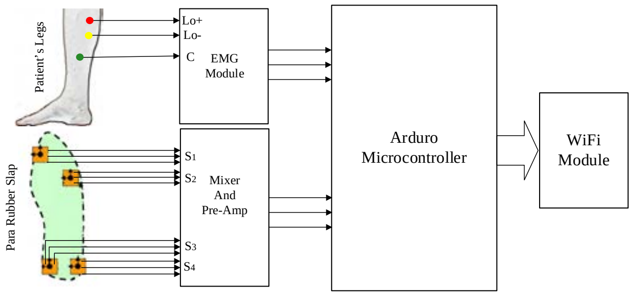

Figure 14. The block diagram of system patient gait analysis.

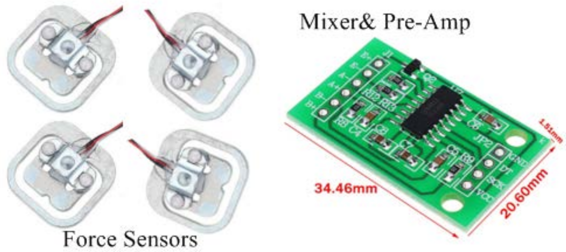

Figure 15. The force sensor and pre-amplifier circuit module.

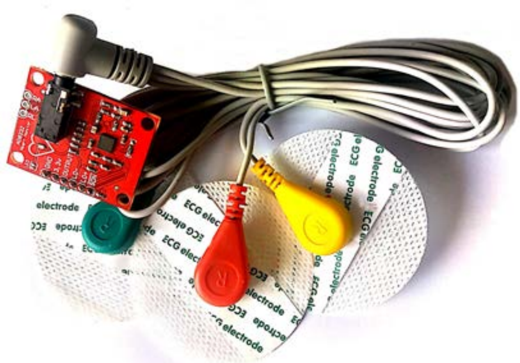

Figure 16. The EMG Module

We have installed a force sensor in the internal slap at heels position of Para rubber slap. Which the physicians can observe the patient's behaviour who wear rubber slap that we can observe from changing the force of the patient's feet. The physicians may diagnose from the top of the EMG signal, along with the pressure of the heel and soles of the feet. Which has the standard value of the patient's body weight as shown in Figure 17 -19.

We can embed the force sensor at the position of the heel and soles of the Para rubber slap, as shows in Figure 20.

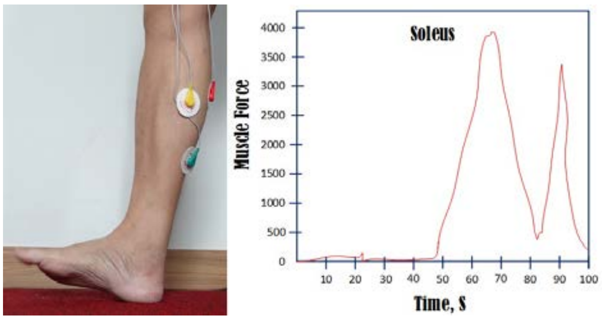

Figure 17. The EMG detects when the patient initially has initial contacted on the floor.

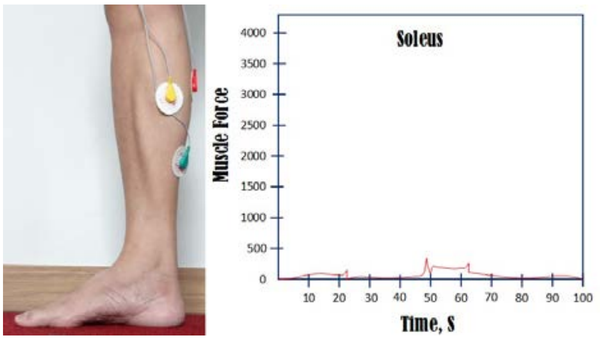

Figure 18. The EMG detects when the patient loading response has contacted on the floor.

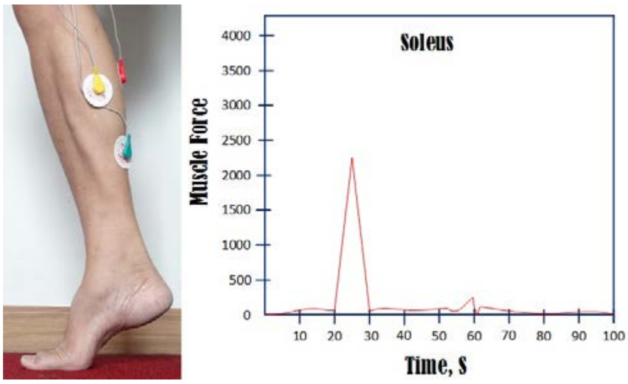

Figure 19. The EMG detects when the patient before leg changing has contacted on the floor

Figure 20. The position of force sensors in Para rubber slap.

2.2.2 The parameter for given to implementation:

They are consists of firstly, Para rubber slap, secondly, force sensors, EMG sensor, electronics devices, and all module which using Arduino microcontroller is the hardware and Android OS are the operating systems for control the following:

a. Receive raw input signals from force and EMG sensors.

b. Record inputs data every step and feed to SD card.

c. Send all data to a smartphone and display the result of the analysis.

Thus, we can set the parameter of slap's construction to install all sensors into four position as shown in Figure 20

2.2.3 Characteristic of Arduino microcontroller which uses in this design:

We consider the use of it as if it is a version of the microcontroller white is suitable for general control or the UNO R3 model is suitable for robot control and the WiFi version is suitable for controlling. The features required for this design includes the following:

a. Specification of Arduino microcontroller is show in Table 2

Table 2. Technical Detail of Microcontroller

Microcontroller	ATmega 328
Operating Voltage	5 Volts
Input Voltage (Recommended)	7 – 12 Volts
Input Voltage (Limits)	6 – 20 Volts
Digital I/O pins	6
DC current per I/O Pin	40 mA
DC current for 3.3 Volts	50 mA
Flash Memory	32KB
SRAM	2KB
EEPROM	1KB
Clock Speed	16MHz

2.2.3.1. Arduino Platform

Arduino consists of two main parts: firstly is the Arduino board, which is a piece of hardware when we create our objects and the second is the Arduino IDE, which is the software we use on the computer/notebook. We use the Arduino IDE to write the code. The draft program that we will upload to the Arduino board to work together with hardware means creating a circuit from the initial design using hundreds of passive and active components such as resistors, capacitors, inductors, transistors and other normal applications in all hardware applications, especially circuits that are wire circuits and in changing circuits, we have to waste time cutting wires or cutting patterns circuits (PCBs), connectors, soldering and others with the use of digital and microprocessor technology by these functions, which were once used to replace wires with software programs.

Arduino Uno R3 is the latest version after Duemilanove with the updated USB interface chip. For example, it not only has the head of the extended protector with 3.3-3.7 volts reference and RESET pin (which fixes the way to the RESET pin in protector) and 500 mA fuse to protect the computer's USB port. But also an automatic circuit to select power USB or direct current without jumper which the shape of the board is shown in Figure 21.

Arduino Uno is a pin and source code that is compatible with older versions of Duemilanove and Arduinos. Therefore, shields, libraries, all of your code will still work. The UNO R3 (3rd update) is slightly updated with Upgrade to USB interface chips and additional breakouts for i2c pins and IO reference pins.

Figure 21. The Arduino UNO R3 board

2.2.3.2. Arduino IDE

Arduino is open-source. There is no copyright for commercial use and distribution of files used to create prototypes for free. Arduino software (IDE) used for development is also distributed for free. We can download it legally, use it, continue to build products and resell, don't waste money on other microcontrollers. There is also free software created by researchers around the world, such as fritzing and processing, etc., resulting in a large community with a lot of free tools to use, both blogs and websites. There are many places in foreign countries that can be found on popular websites such as arduino.cc, or instructables.com. These websites give out sketches and installation files for free. Create and find materials around us. IDE (Integrated Development Environment) is a special program that runs on a computer/notebook that allows researchers to write control programs for Borg R. Dannio using simple language and for modeling after processing. The magic happens when we press the button that uploads the code that we write to the Arduino board, where the source code that we write will be translated into C-Language and will be passed to the compiler named avr-gcc, which is an important part of opening the source software that makes the final translation into the language of the microcontroller itself. This last step is quite important because the Arduino IDE makes our programming easier by overlapping the complexity of microcontroller programming as shows in Figure 22.

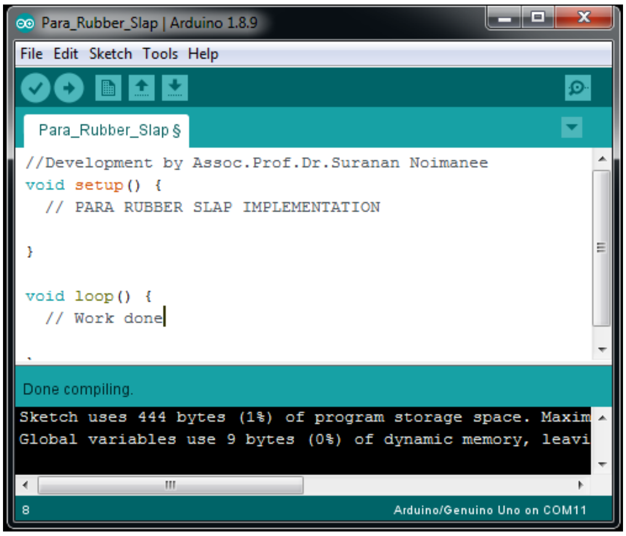

Figure 22. The Arduino IDE

2.2.4 Considering the results of observations, measurement of pressure on the floor and EMG obtained from patients with Para rubber slaps:

2.2.4.1 The Force and EMG Analysis

The force and EMG analysis is an method using Fast Fourier Transform techniques as well as many traditional force and EMG analysis methods making it especially suitable for this application is developed from the basic EMG graphing program using raw data from Arduino's data acquisition system, which can be processed and exported to medical applications for further analysis via Wifi or standard files for example, standard ASCII format which is compatible with Excel, or MATLAB etc.

This is one of the most powerful, yet easy to use, software packages using FFT analysis that is available to both the clinician and researcher.

The program reads force raw data directly from Arunio board output and calculate.

Types of human foot pressure analysis divided into two types: Firstly type is Static Analysis and secondly is Dynamic Analysis which we use the second type of analysis because the physician's practitioner would like to know the convenience of wearing Para rubber slap that is convenient or not. In static analysis, the vector sum of all the forces of human actions on the human foot is zero and the vector sum of all the moments about any arbitrary point is zero. In a ground planer system, forces can be described by two-dimensional vectors and therefore:

$$\sum F_x = 0 \tag{9}$$

$$\sum F_y = 0 \tag{10}$$

$$\sum T_z = 0 \tag{11}$$

The human legs of the action of two forces will be in balance if the forces are of the same magnitude, the forces act along the same line, and the forces are in opposite directions therefore the summing of force equal zero as shown in Figure 23.

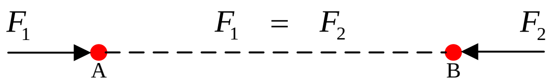

Figure 23. The component of force

From force equals mass time acceleration, weight is a force and it can replace force in the previous equation. The acceleration would be gravity, which is an acceleration. We use Fast Fourier Transform (FFT) for analysis this work because the majority and minority of the design method are made of force and EMG sensor, so most FFT calculations involve strain gage force sensor components. The analysis of force sensor components can be carried out by either linear or nonlinear stress analysis. Which analysis approach you use depends on how far you want to push the design. If we want to ensure the position of force sensors remains in the linear elastic range, we must carry out using nonlinear stress analysis methods. When the observed analysis is used by FFT methods to analysis the EMG displacement on the legs of the patient due to his/her walking on the floor with comfortable. The physician has to use these methods for analysis.

3. RESULT

The results showed that the samples patients were satisfied with the use of Para rubber slaps. With this Para rubber slap to help prevent and relieve the toe drop not turning up the ankle. Helps stretch the ankle muscles, and helps to limit movement during the time when the bone is still not attached. Which is a medical prototype product that can continue to develop other medical developments made from Para rubber is shown in Figure 24. with patients wearing a Para rubber slap that embedded an internal force sensor.

Figure 24. Patients wearing Para rubber slab from this research.

Anyway, the results were that a prototype of intelligent Para rubber slap design by my researcher teams using special software which is the personal size for each patient who wearing it that he/she can use in MSMC or home location. In this analysis, we use FFT to analyzed calculate the force and EMG while the patient gait on the floor. This work is running to solve using the FFT and obtains the result through the post-processing: the altitude deformation figure of the height from the ground-adjustable the application program at the optimum alignment is shown in Figure 25 - 28.

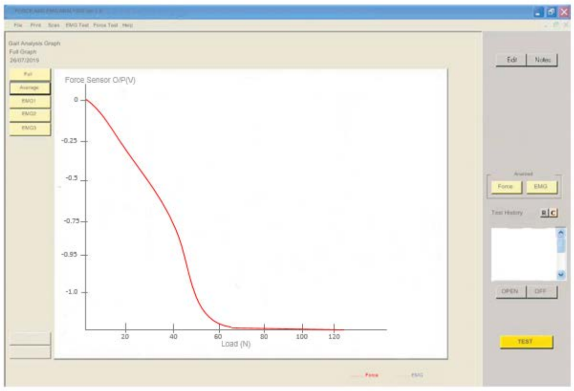

Figure 25. Total force wearing Para rubber slab while he/she contact on the floor.

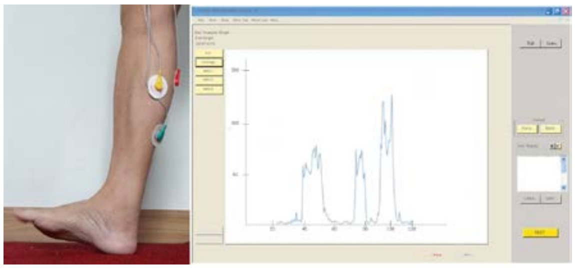

Figure 26. The EMG detects when the patient initially has initial contacted on the floor by experiment at MSMC.

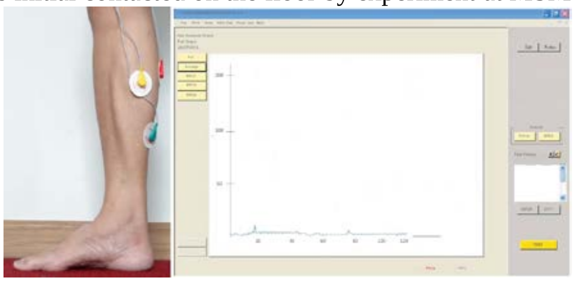

Figure 27. The EMG detects when the patient loading response has contacted on the floor by experiment at MSMC.

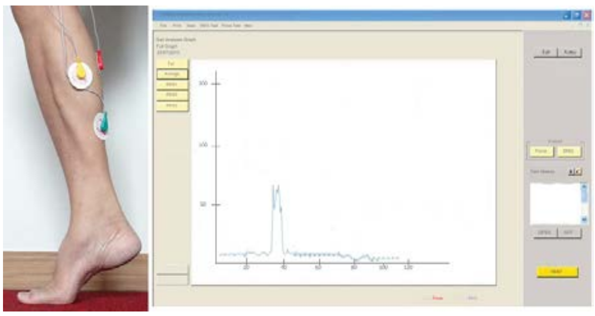

Figure 28. The EMG detects when the patient before leg changing has contacted on the floor by experiment at MSMC.

4. CONCLUSION

This paper has designed a new intelligent Para rubber slap for the orthopedic patients who while wearing the Para rubber slap in MSMC Thailand and then a comprehensive Fast Fourier Transform (FFT) has been conducted using special software on this analysis. The results of the analysis have shown that this design found that the reliability and stability of comfortable requirements, verifying the rationality of this structured design. The way of using special software to conduct a prototype analysis and check for designing work is simple, practical, high efficient, highly shorting the production cycle and reducing the research and development costs. This method is worthy of further extension.

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