MECHANOMYOGRAPHY – AN INDIGENOUSLY BUILT SYSTEM FOR QUANTITATIVE ASSESSMENT OF MUSCLE STRETCH REFLEX

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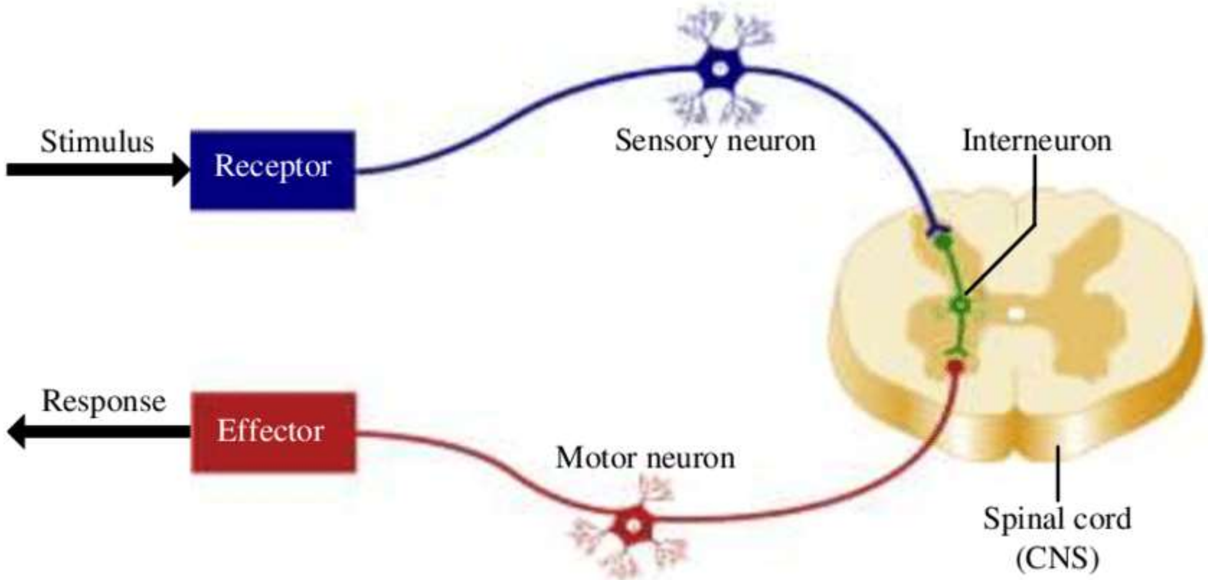
INTRODUCTION

Stretch reflex is the contraction of a muscle in response to the stretch.

Reflex is a inborn, involuntary, stereotypic response to a stimulus – Executed through a reflex arc.



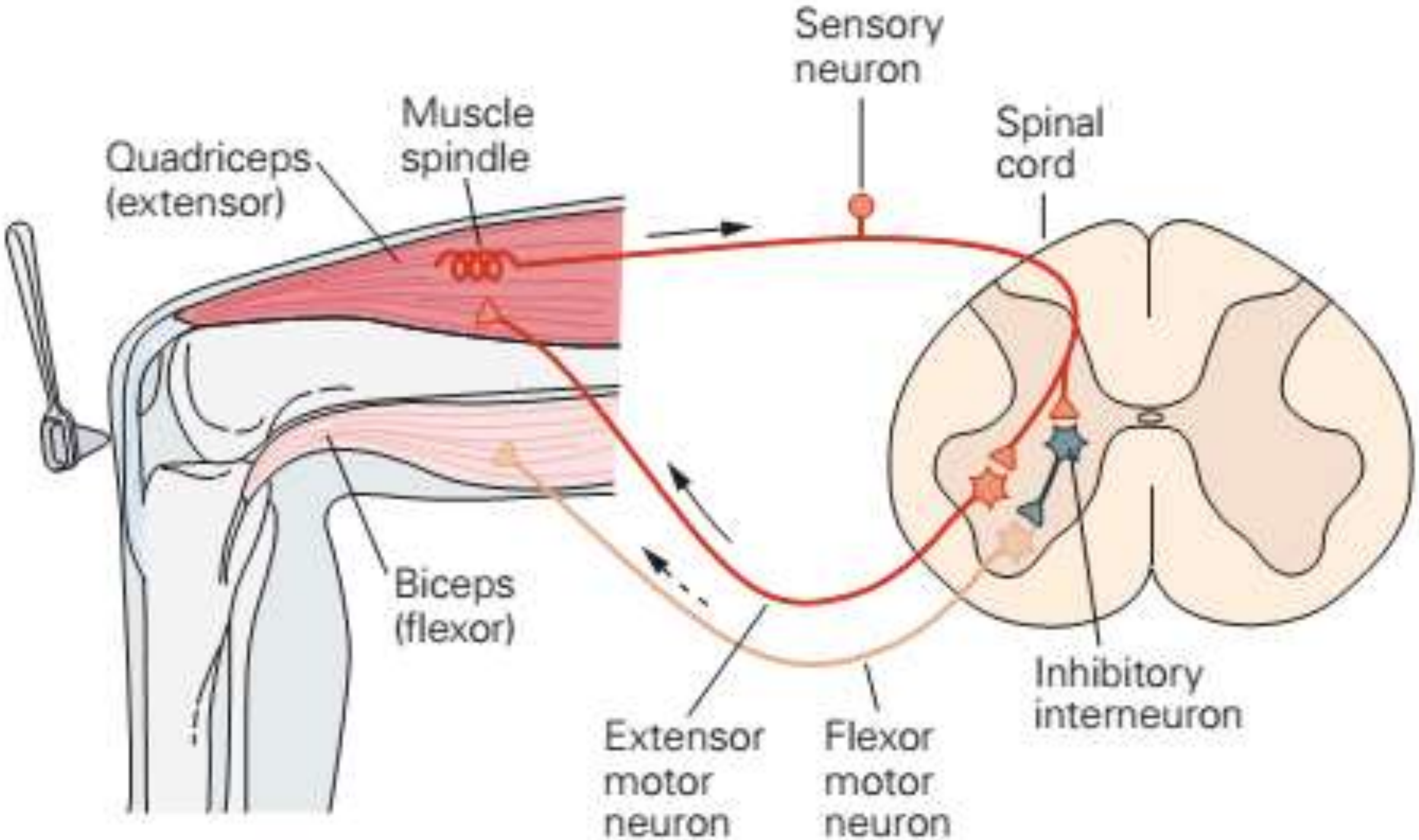
- Phasic stretch reflex
- Tonic stretch reflex

Phasic stretch reflex occurs in response to rapid, transient stretch.

Tonic stretch reflex occurs in response to a steady stretch applied to the muscle.

Patellar tendon reflex (PTR) is one of the Phasic muscle stretch reflexes (MSR) evaluated during the clinical examination.

PATELLAR TENDON REFLEX (PTR)



- Various pathological conditions causes an alteration in the predictable response of the stretch reflexes[1,2]
- Diabetes is one of the complications that can decline the skeletal muscle function[3,4]
- Hyperglycemia damages muscle fibers and results in loss of muscle mass & strength[5] – Diabetic myopathy.
- The magnitude of the reflex response might be reduced due to decrease in the force generated by muscle during contraction.

Therefore, it is essential to distinguish a normal reflex response from an abnormal response.

In clinical practice, assessment of these reflexes are carried out by reflex grading scales (NINDS scale)

However, these reflex grading scales are qualitative, subjective and lack temporal data.

In addition, the grading of the reflex purely depends on the visual judgment of the examiner.

REFLEX GRADING SCALES

Table 2 NINDS scale for tendon reflex assessment[1]

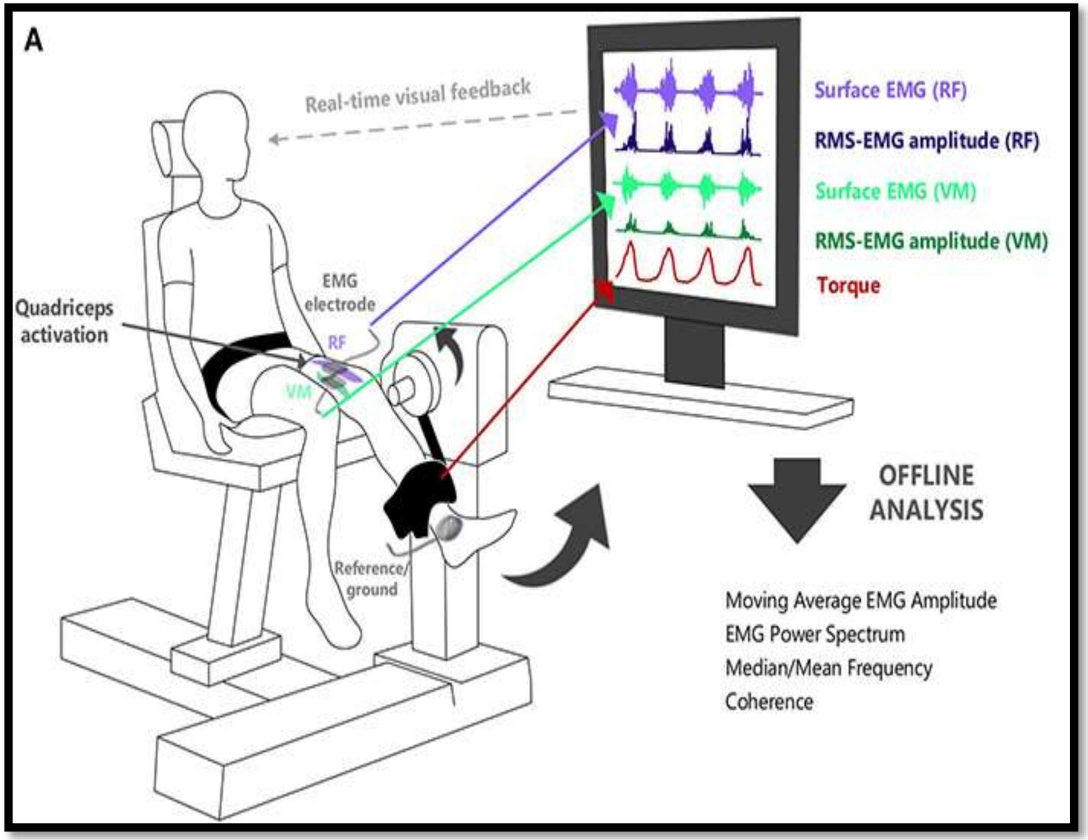
Description	Score
Reflex absent	0
Reflex slight, less than normal: includes a trace response or a response brought out only by reinforcement	+1
Reflex in lower half of normal range	+2
Reflex in upper half of normal range	+3
Reflex enhanced, more than normal: includes a clonus if present which optionally can be noted in an added verbal description of the reflex	+4

Table 1 Mayo Clinic scale for tendon reflex assessment[3]

Description	Score
Absent	−4
Just elicitable	−3
Low	−2
Moderately low	−1
Normal	0
Brisk	+1
Very brisk	+2
Exhaustible clonus	+3
Continuous clonus	+4

EMG

Human Motion analysis



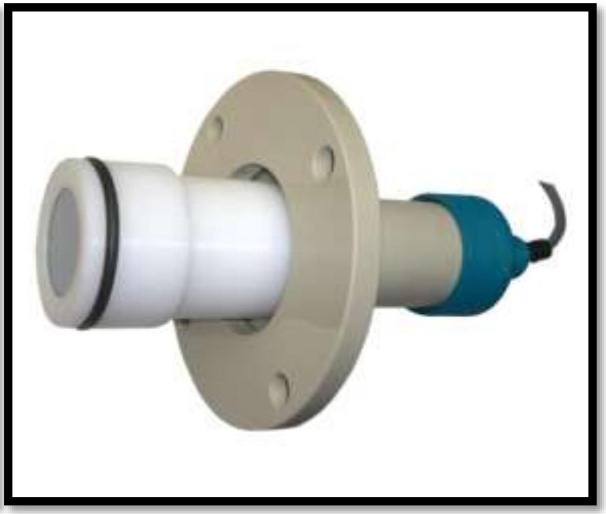
MECHANOMYOGRAPHY (MMG)

- MMG can detect mechanical oscillations (Dimensional changes) generated by muscle contraction from the surface of the skin[6].
- MMG is a non-invasive tool that utilizes transducers such as accelerosensor, laser distance sensors or acoustic sensors[7].

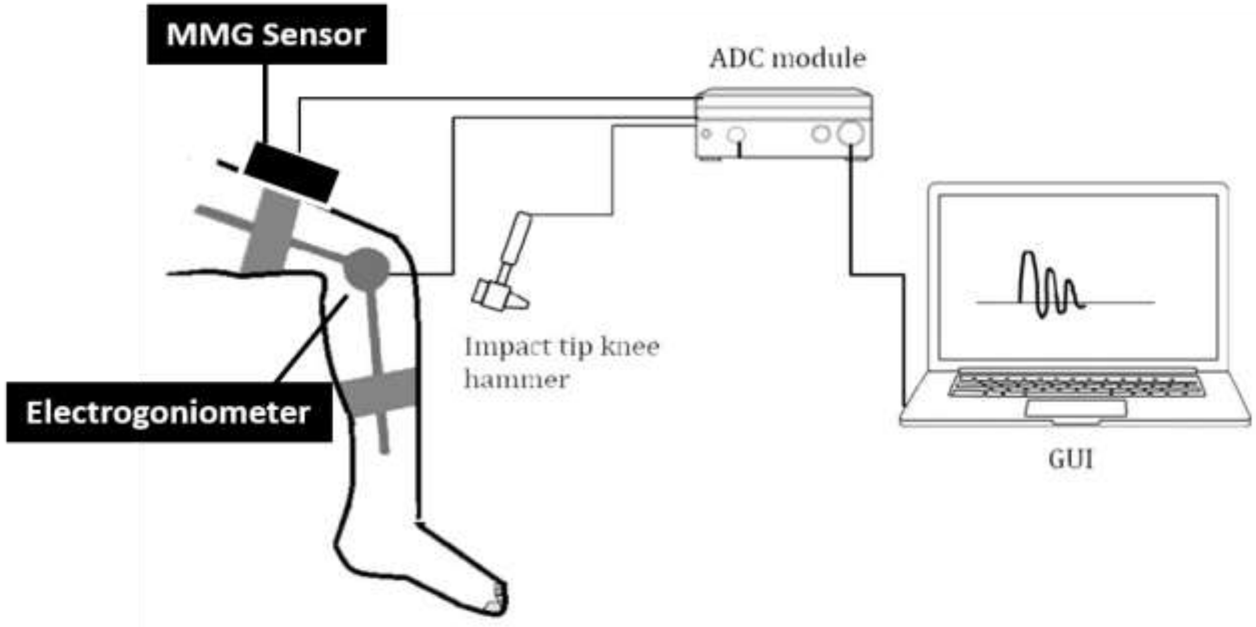
Accelerosensor

Laser displacement sensor

Acoustic sensor



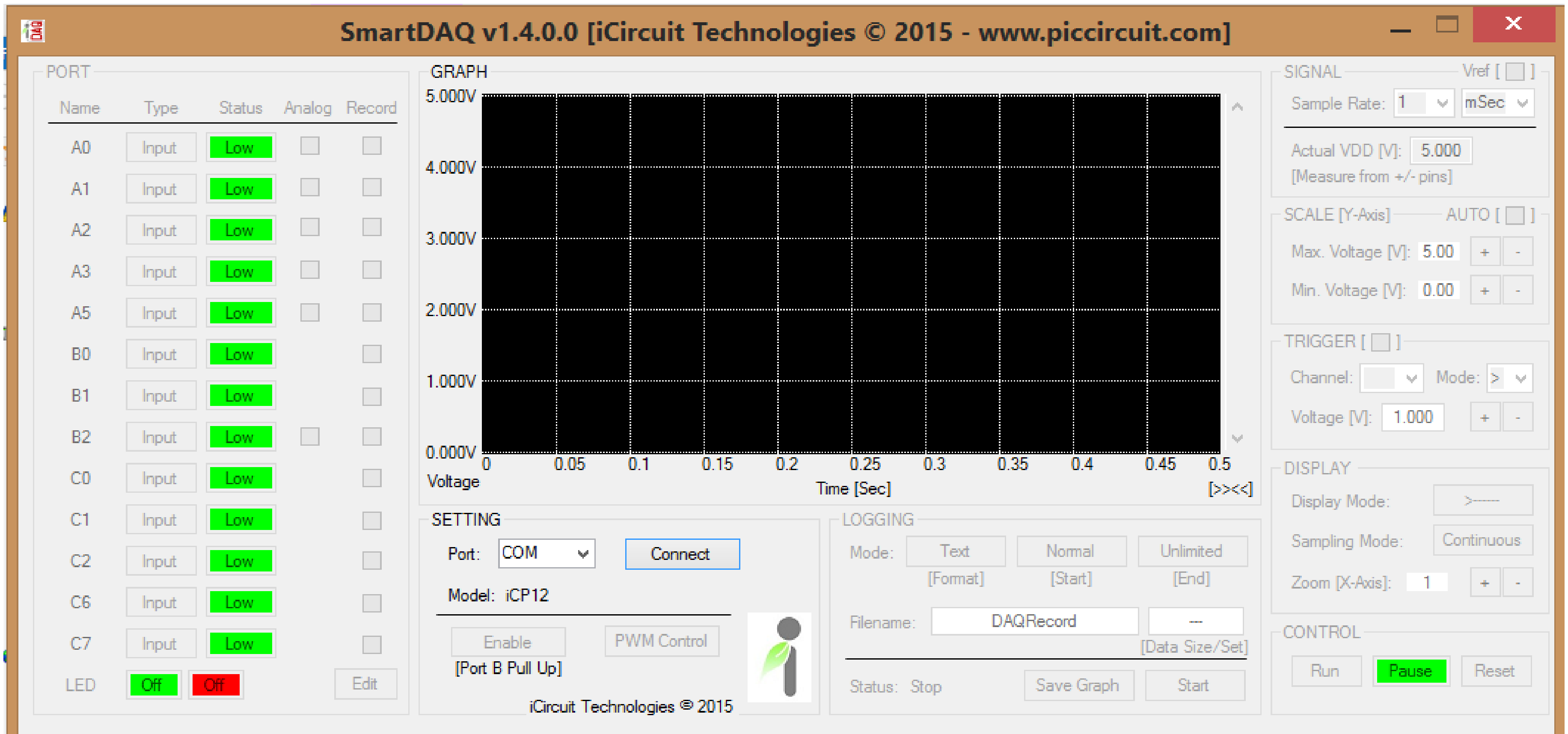
DESIGN OF THE SYSTEM



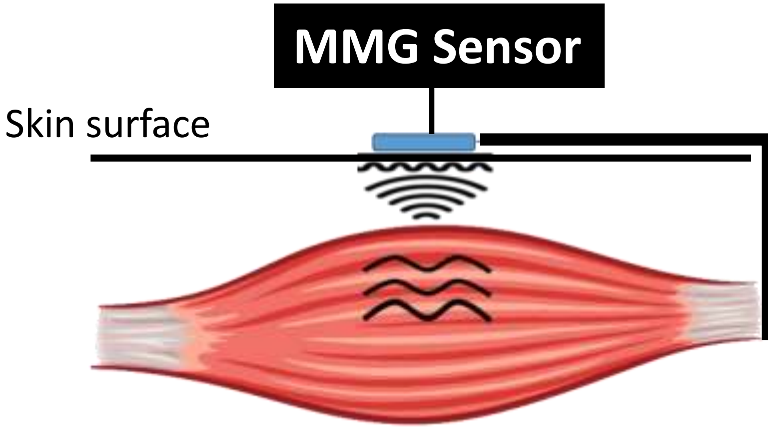
- MMG signals were measured using Accelerosensor (ADXL335) manufactured by Analog Devices Inc (US).
- This sensor can convert mechanical oscillations during muscle activity into analog signals (Voltage data)
- The signals from the sensors captured by ADC (Analog to Digital converter) module.

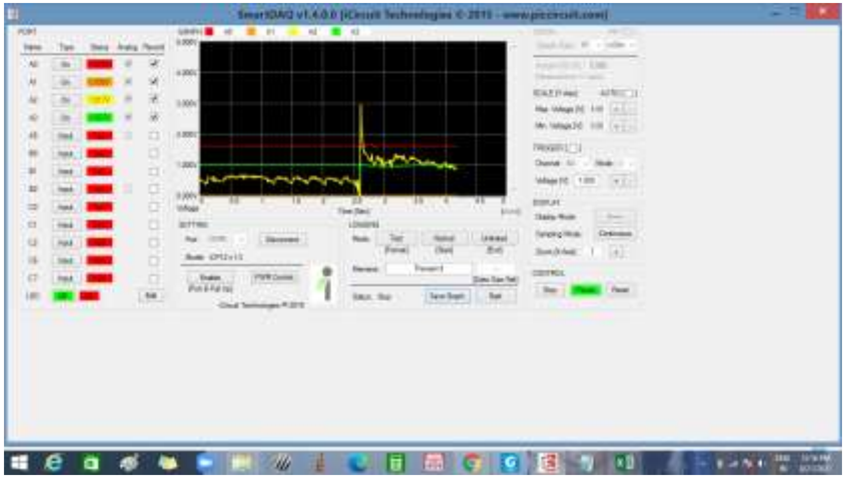
DATA ACQUISITION

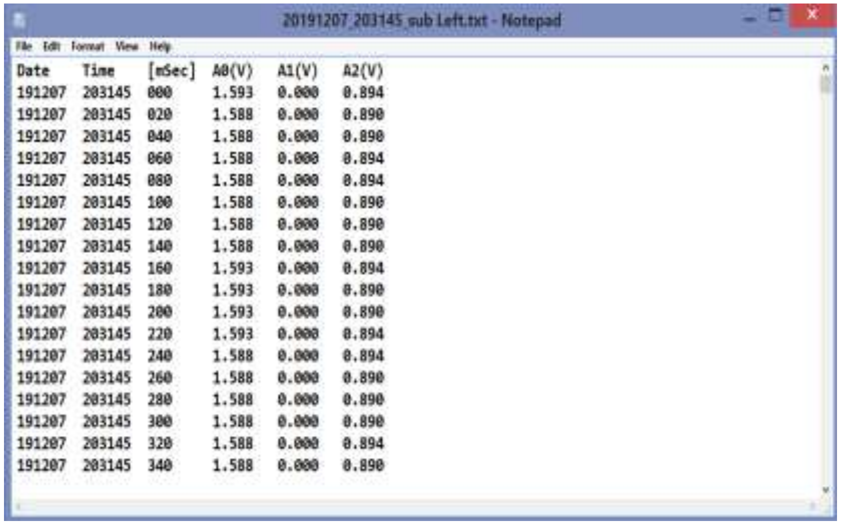
Data acquisition can be done using SmartDAQ V1.4 software application (Open source software).



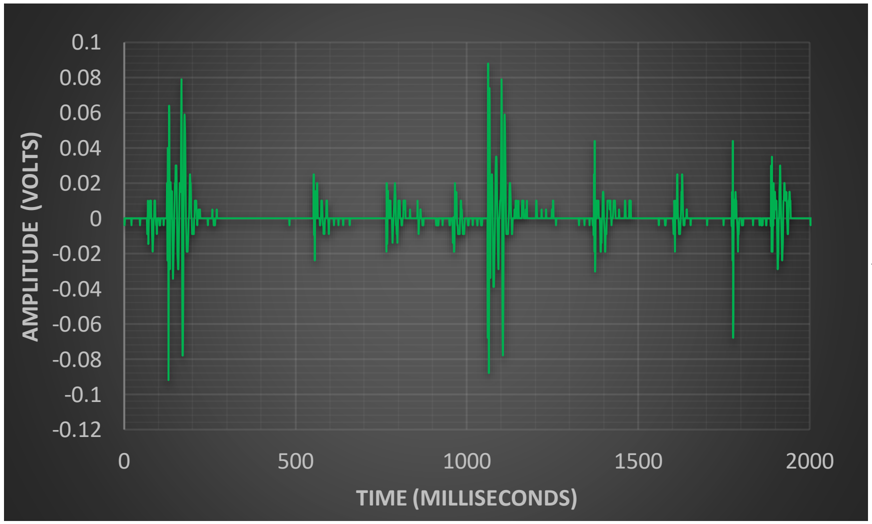
DATA ACQUISITION



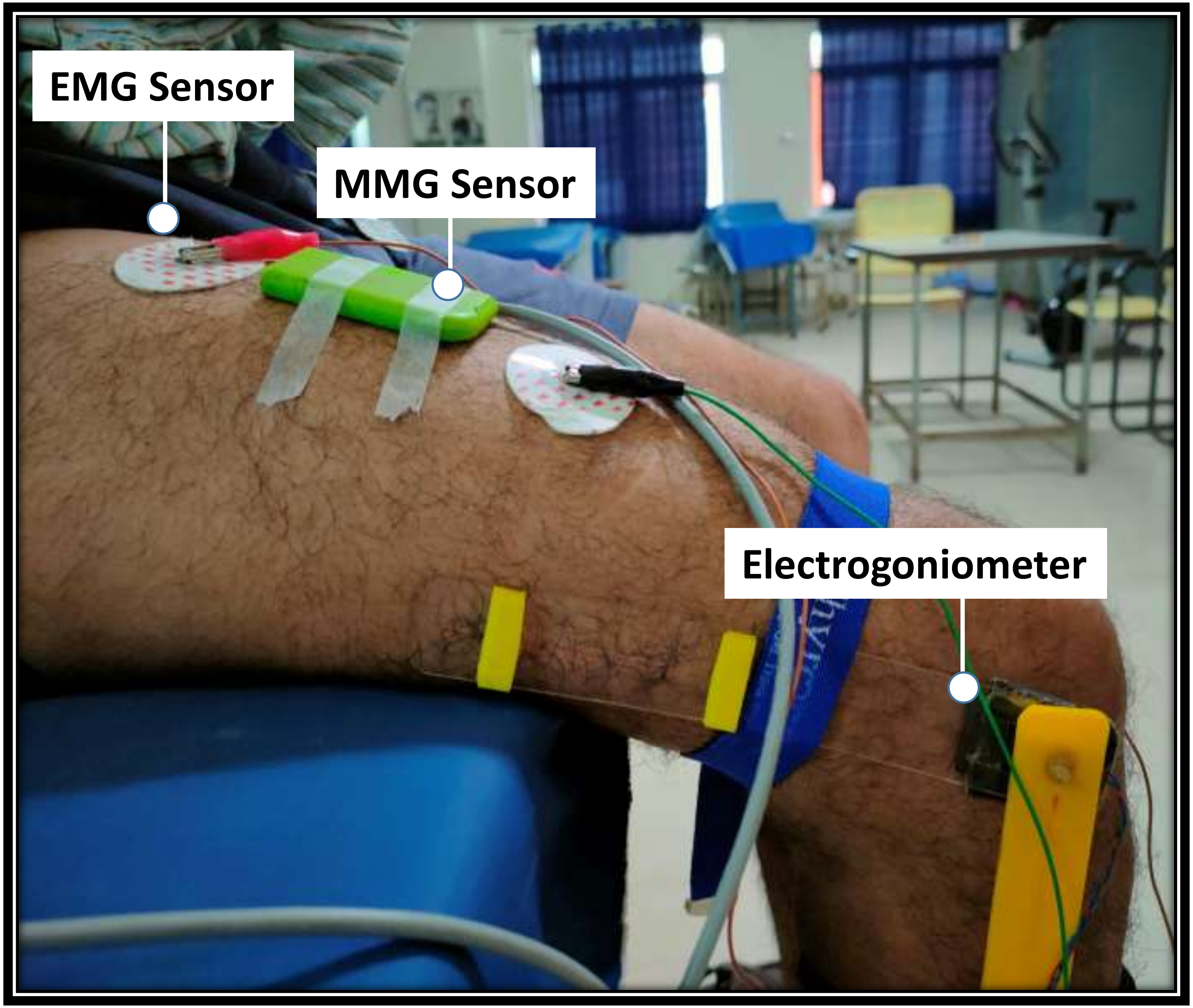




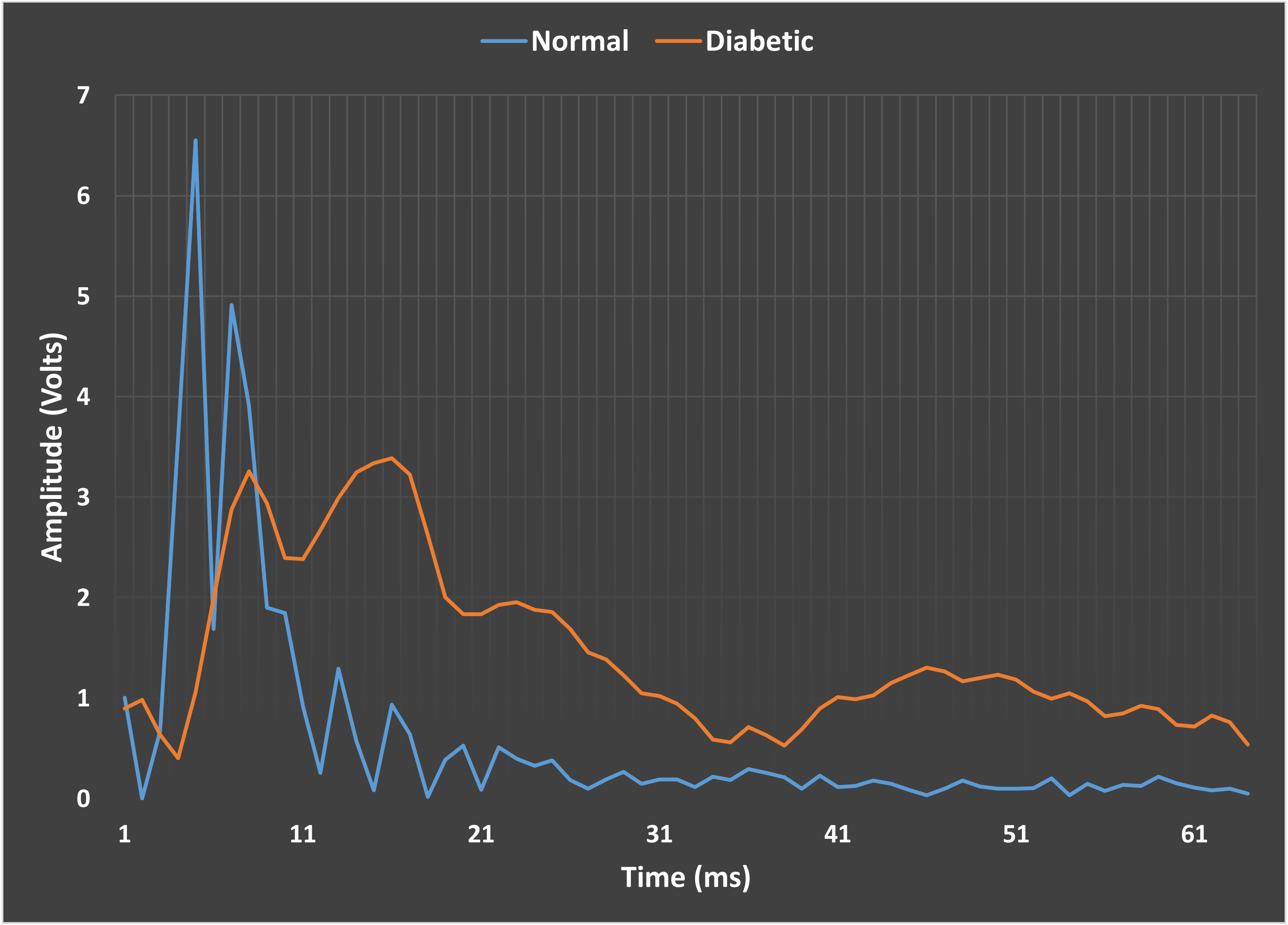
Date	Time	[mSec]	A0(V)	A1(V)	A2(V)
191207	203145	000	1.593	0.000	0.894
191207	203145	020	1.588	0.000	0.890
191207	203145	040	1.588	0.000	0.890
191207	203145	060	1.588	0.000	0.894
191207	203145	080	1.588	0.000	0.894
191207	203145	100	1.588	0.000	0.890
191207	203145	120	1.588	0.000	0.890
191207	203145	140	1.588	0.000	0.890
191207	203145	160	1.593	0.000	0.894
191207	203145	180	1.593	0.000	0.890
191207	203145	200	1.593	0.000	0.890
191207	203145	220	1.593	0.000	0.894
191207	203145	240	1.588	0.000	0.894
191207	203145	260	1.588	0.000	0.890
191207	203145	280	1.588	0.000	0.890
191207	203145	300	1.588	0.000	0.890
191207	203145	320	1.588	0.000	0.894
191207	203145	340	1.588	0.000	0.890



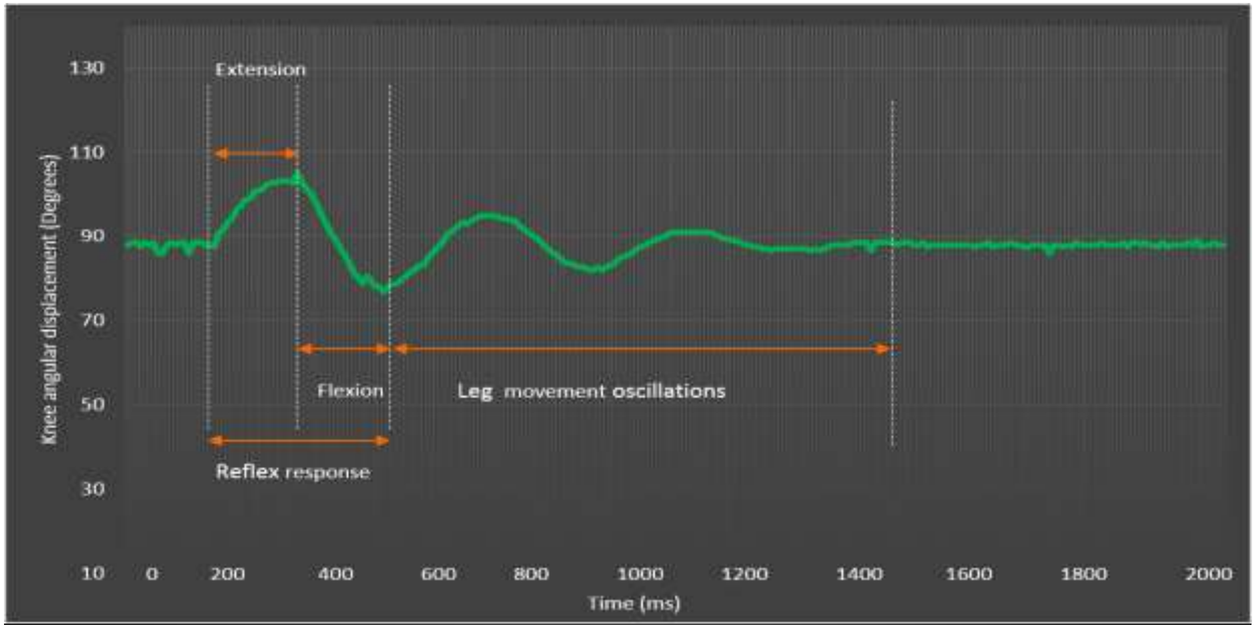
EXPERIMENTAL PROCEDURE

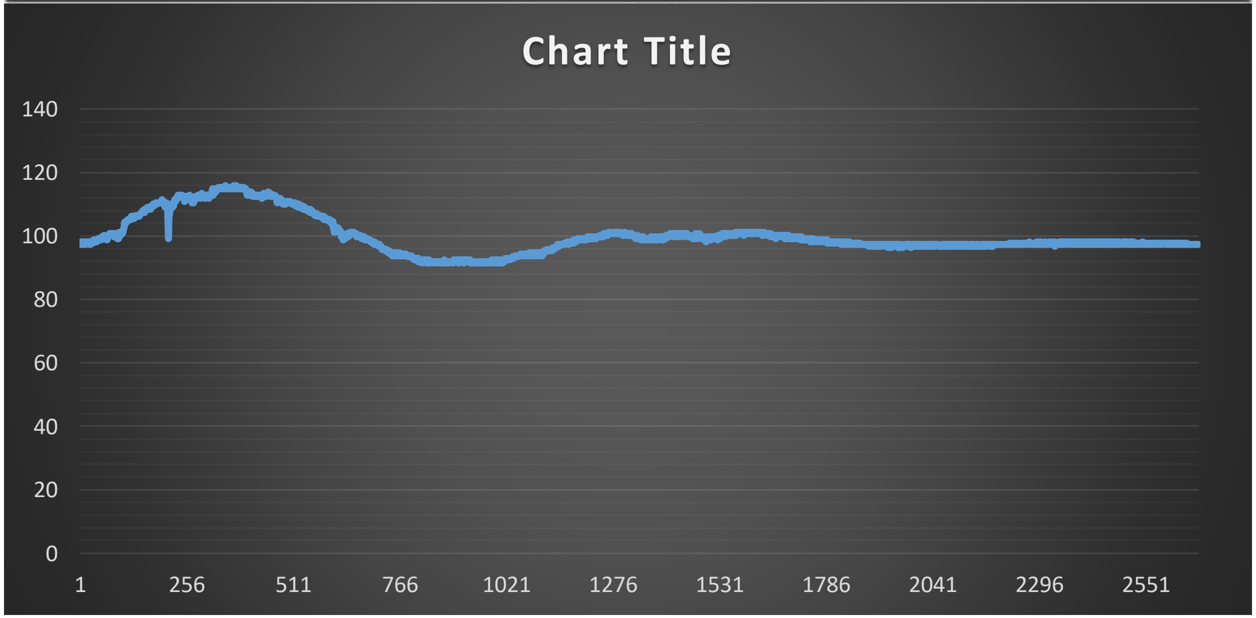


COMPARISON OF STRETCH REFLEX AMPLITUDE



COMPARISON OF KNEE ANGULAR DISPLACEMENT





S.NO	OUTCOME VARIABLES	UNITS	DEFINITION
1.	Movement latency (ML)	Milliseconds	Duration from the point of tendon tap to the onset of first movement of leg into extension.
2.	Total PTR response time (TPTR)	Milliseconds	Duration of total deep tendon reflex response.
3.	Resting angle (RA)	Degrees	The absolute angle at the Knee or Ankle in resting position
4.	Peak extension angular displacement (PEAD)	Radians	Maximum angular change in the response curve from the baseline to the peak (Degrees of knee extension)
5.	Peak flexion angular displacement (PFAD)	Radians	Maximum angular change in the response curve from the peak to the baseline (Degrees of knee flexion)
6.	Angular velocity (AV)	rad / sec	Rate of angular displacement occurring due to biomechanical movement during PTR response
7.	Peak – to- Peak amplitude	Millivolts	Difference between highest amplitude value and lowest amplitude value
8.	MMG Amplitude	Volts	Amplitude of muscle activity
9.	MMG Frequency	Hz	Frequency of muscle oscillations
10.	Reflex mediated peak EMG amplitude	Millivolts	Reflex-mediated peak EMG signal of the quadriceps muscles
11.	Tendon tap force (TTF)	Newtons	Degree of impact force measured during tendon

ADVANTAGES

- Non-invasive tool
- Can yield quantitative data
- Inexpensive
- Portable
- No skin preparation is required – Less discomfort to the patient
- Can not be influenced by external noise

LIMITATIONS

- The data is processed offline due to which real time results are not possible.
- Data processing is tedious
- The device usage requires minimal computer knowledge.
- Needs to verify its accuracy in different clinical scinarios.

APPLICATIONS OF MECHANOMYOGRAPHY

- MMG can be applied to measure the fatigue threshold.
- Useful tool in clinical diagnosis in various rehabilitation interventions.
- To study the muscle function during dynamic activities such sports activities.
- To monitor training induced changes in muscle power output and other areas of muscle function assessments.
- To diagnose neuromuscular and neurological diseases
- Assessment balance and gait analysis.
- It is applicable to all population (Paediatrics to Geriatrics) and to all form of muscle activities (Static and Dynamic muscle contractions)

SUMMARY

- MMG is a non-invasive indicator of muscle function of experimental and clinical importance.
- The MMG along with electromyography provides an useful quantitative data of muscle stretch reflexes.
- The information of MMG signal frequency and knee angular velocities could provide a valuable information.
- It has more advantage compared to the conventional qualitative reflex grading scales.
- Inexpensive, and user friendly, screening tool that can be utilized clinical practice.

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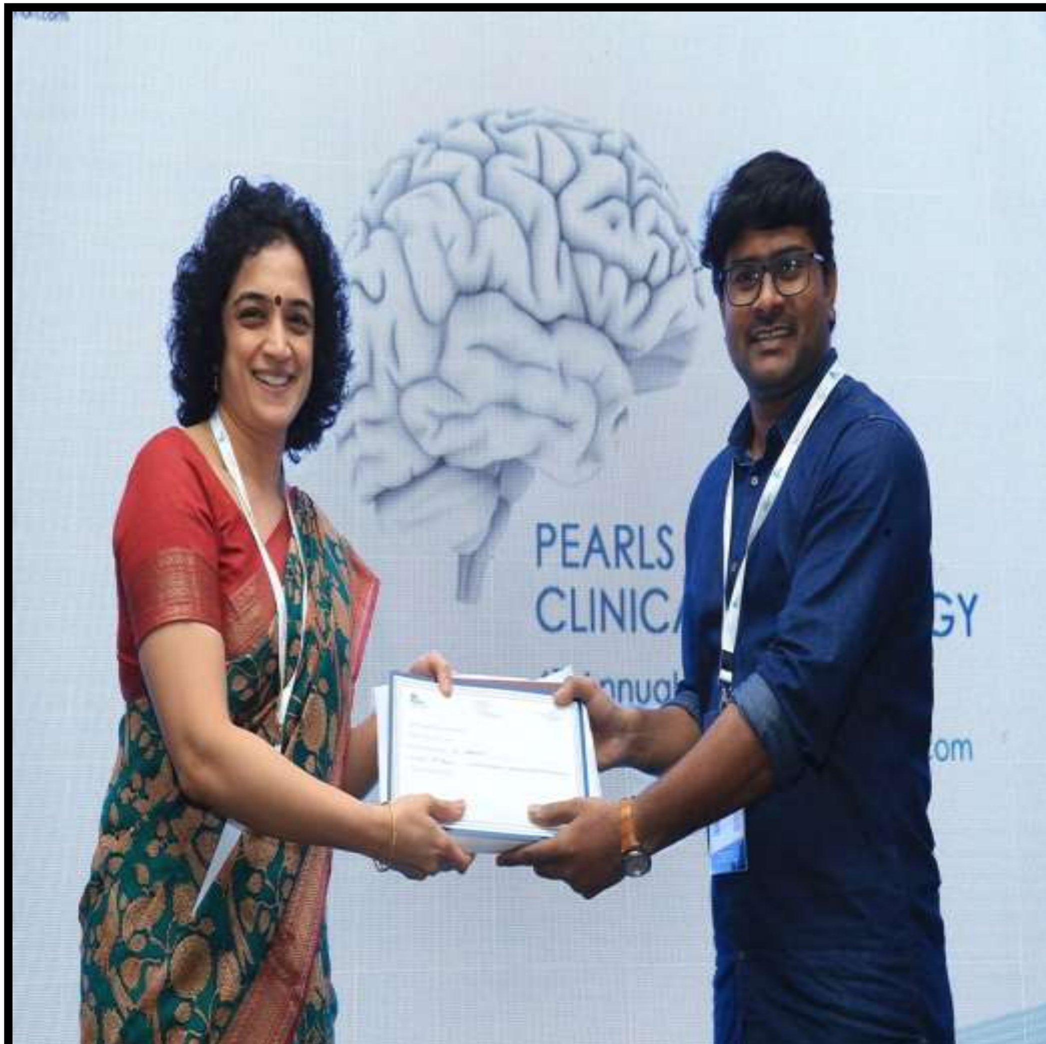
- Dr. K.N. Maruthy for designing & fabrication of the device and also for continuous encouragement.

BEST POSTER PRESENTATION



PUBLICATIONS

ORIGINAL PAPER
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Summary

Background: Assessment of deep tendon reflexes such as patellar tendon reflex (PTR) is the vital diagnostic procedure executed routinely by clinicians which can provide valuable information about the reflex arc. Despite common acceptance, the reflex rating scales remain subjective and qualitative, creating an opportunity for the development of objective measures to improve the reliability and efficacy of these clinical tools.

Material and methods: The proposed study presents with reflex quantification system for knee jerk response using electrogoniometer and accelerometer. These sensors are capable of detecting dynamic changes occurring in the movement of an object and they can convert biomechanical information of movement into digital signals. The proposed system utilizes this technology to assess knee jerk response and provide quantitative data on various aspects of the knee jerk.

Results: The dynamic action of the leg during knee jerk response created movement patterns which were captured by the utilization of the data acquisition system. Based on the reflex response of the leg, the frequency of analog signals from biomechanical sensors as well as the amplitude of the graph was changed. Components of knee jerk response such as Reflex Movement latency (RL), Jerk time (JT), Total reflex response time (TRT) and Reflex amplitude was recorded from the data obtained.

Conclusion: This study presents the method of patellar tendon reflex response measuring system based on computational data acquisition system using wearable sensors. This methodology can be used as a additional tool in clinical assessment of deep tendon reflexes. The main advantages of the proposed system are its portability, user-friendly and non-invasive nature.

Keywords
Accelerometer – Electrogoniometer – Knee jerk – Biomechanical response – Reflex latency – Reflex amplitude

ORIGINAL PAPER

A newer approach for quantitative assessment of patellar tendon reflex response using biomechanical data of foot movement by a digital method

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Background

Deep tendon reflex (DTR) also known as myotatic stretch reflex is a monosynaptic reflex. A stretch reflex is an involuntary response of a muscle to passive stretch. Eliciting tendon reflexes is an important screening tool in assessing the integrity of the neural system [11]. This test is commonly used in clinical practice because it is a simple procedure and can be performed quickly with ease. Assessment of DTR is routinely used to evaluate various clinical conditions such as stroke, traumatic brain injury, peripheral neuropathy and thyroid dysfunctions [9]. One of the major disadvantages of the traditional clinical examination of tendon reflex test is variability within the subject and between subjects [15,14]. Conventionally the tendon reflexes are described in qualitative terms such as brisk, sluggish or expressed in semi-quantitative rating scales in the form grading [13]. Tendon reflexes are clinically evaluated by reflex grading scales such as NINDS (National Institute of Neurological Disorders and stroke) scale or by Mayo clinic scale. These scales lack temporal data and may also vary in elucidation [6]. Besides, the inter-observer reliability of these scales is uncertain [8]. This intrinsic disadvantage of qualitative assessment of DTRs emphasizes the need for the implementation of objective methods. The electro-diagnostic techniques like EMG (Electromyography), Nerve conduction studies are widely used to quantify tendon jerks but these methods are subject to difficulties concerning the placement of electrodes, need expensive experimental setups and restricted only to research institutes and specialized clinical setups [10]. Hence, improved methods and instruments are required to guarantee quantitative evaluation of the tendon reflex test in clinical practice. This paper

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Characterization of the patellar tendon reflex response using an indigenously developed system and implementation of a strategic protocol to assess its clinical usefulness

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ABSTRACT

Introduction: Deep tendon reflex evaluation is a part of the neurological examination and a wide variety of neurological and neuromuscular disorders manifest alterations in deep tendon reflex responses. Conventional methods to assess tendon reflexes in clinical practice are subjective and provide categorical data that might not be adequate in the interpretation. Hence, a quantitative tool is warranted to provide an objective outcome of tendon reflex assessment. The goal of this work was to use an indigenously designed method to characterize the tendon reflex responses.
Materials & methods: A cross-sectional study was undertaken in 40 healthy subjects aged between 20 and 45years. Assessment of the tendon reflex was performed using wearable biosensors to characterize it into quantitative variables. A strategic protocol was followed to test the accuracy and repeatability of the outcome.
Results: Analysis of phase – I results of the subjective assessment showed high interrater variability and significant bilateral PTR test variability. Whereas the results of the objective assessment showed that the bilateral PTR test variability is minimal by both the assessors. However, the results of all quantified PTR test variables showed an insignificant inter-observer variability except for T 1, TTE and PEAD ($p < 0.05^*$).
Conclusion: The findings of this study suggest that quantified tendon reflex using wearable biosensors could provide a piece of valuable information during neurological examination in clinical settings. The proposed tendon reflex quantification tool is non – invasive, portable and inexpensive that can be used for field studies in different clinical conditions.

1. Introduction

Reflex is a inborn, involuntary and stereotypic response to a stimulus, and for any reflex to be present, an intact reflex arc is a must.[1] The evaluation of deep tendon reflexes (DTR) is one of the essential components in clinical examination of the nervous system. Assessment of these tendon reflexes is an essential clinical tool for diagnosing and localizing neurological and neuromuscular disorders.[2,3] Patellar tendon reflex (PTR) is a simple and conveniently performed tendon reflex test.[4] Pathological alterations in these reflexes are important signs of neurological diseases and distinguishing between delayed or exaggerated PTR responses may help to detect neurological disorders.[5,6] The reflex latency and amplitude of PTR response may vary in people with neurological, neuromuscular, and endocrine disorders.[7,8] Therefore, observation of irregularities in kinematics of tendon refelexes provides valuable insight into the diagnosis and prognosis of the patient's neurological condition. However, the conventional approach to assess the tendon reflexes using semi-quantitative reflex grading scales depends on the examiner's visual judgment.[9,10] NINDS (National Institute of Neurological Disorders and Stroke) and Mayo clinic reflex grading scales are two widely accepted ordinal scales utilized for the PTR assessment.[11] But, these scales lack temporal data and have high inter-rater variability.[12,13] Therefore, improved tools and techniques are required to quantify PTR responses accurately to enhance the utility of DTR examination. The objective of this study was to improve the clinical utility of DTR examination by quantifying the PTR kinematic features

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Thank you!