AM5023- PHYSIOLOGICAL MEASUREMENTS AND INSTRUMENTATION LABORATORY

NIID- LABORATORY REPORT

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BLOOD PRESSURE MEASUREMENT AND ANALYSIS OF BP VARIATIONS UNDER DIFFERENT PROTOCOLS

Aim

The aim of this experiment is to record BP measurement with sitting, supine and standing position.

Objective

To use digital sphygmomanometer to analysis data under different condition.

Apparatus required

- BP cuff (Medium size)
- Digital sphygmomanometer (Company: Circa, Model: Eris Microlife)
- Clock

Theory

Most automated NIBP devices are based on oscillometry, measures mean arterial pressure and use an algorithm to estimate the systolic and diastolic blood pressure. The cuff is inflated above systolic pressure and then deflates either continuously or in a stepwise manner. As the cuff pressure decreases, at a rate about 4 mm Hg per second, below occlusive pressure, blood starts flowing through the artery and causes detectable oscillation. The pulse pressure wave and the gauge pressure in the occluding cuff are detected and converted into an electronic signal by a transducer. The pressure at which the peak amplitude of arterial pulsations occurs corresponds closely to directly measured mean arterial pressure (MAP), and values for systolic and diastolic pressure are derived.

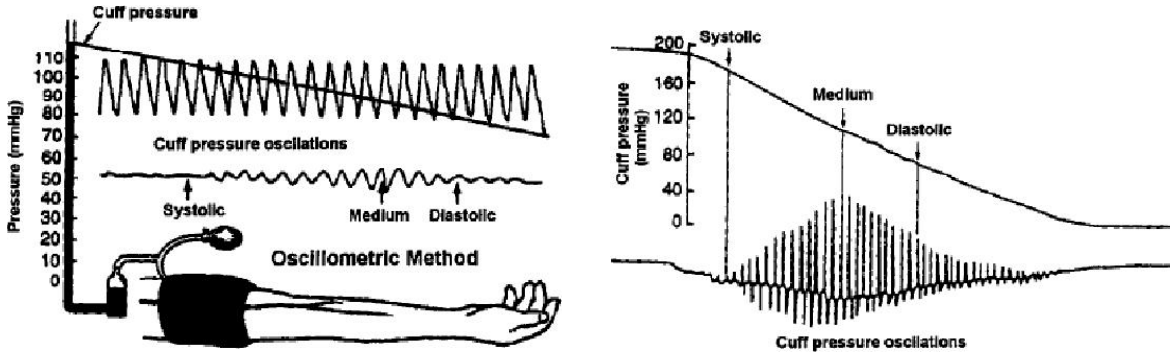


Fig 1. Blood pressure determination using oscillometric method

Method

Follow the instruction written in manual. BP should not be taken on empty stomach. Take rest 5 min before taking BP measurement. BP cuff should be placed over the Brachial artery. Cuff should not be too loose or too tight. Digital sphygmomanometer does not require a stethoscope and it's reading doesn't depend on the hearing ability of observer. It automatically inflates the cuff till artery gets occluded after that cuff is deflated automatically.

Reading is taken for 3 time to get better accuracy.

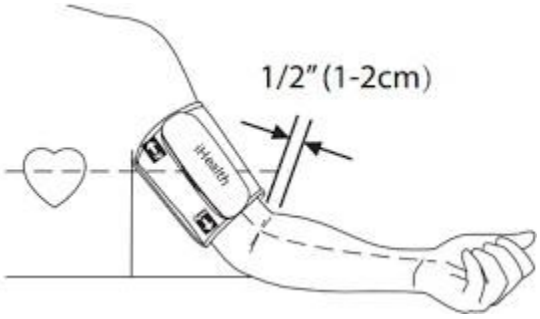


Fig 2. Cuff position

BP is taken two times a day in standing, sitting and supine position. Data is recorded for 10 days to observe the variation in BP under different condition.

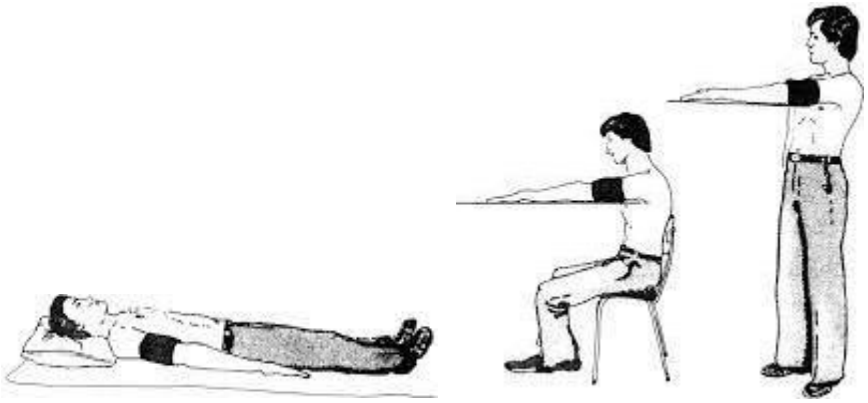


Fig 3. Different Position for BP measurement

Sitting blood pressure is taken from the left arm, flexed at the elbow and supported at the heart level on the chair. After at least one minute of standing, the blood pressure is then taken standing, with the arm supported at the elbow.

The cuff should be at the heart level. After one minute of rest, the blood pressure was subsequently taken supine position.

Results

Systolic Pressure							
		Day time (9:00 AM to 10:00AM)			Evening Time (4:00 PM to 5:00PM)		
Date	Reading	Sitting	Supine	Standing	Sitting	Supine	Standing
25/10/23	1	99	98	107	103	101	104
	2	100	95	107	101	102	104
	3	96	99	106	100	98	106
	Average	98.33	97.33	106.67	101.33	100.33	104.67
27/10/23	1	105	102	108	105	101	108
	2	104	101	100	103	108	107
	3	105	103	102	101	101	111
	Average	104.67	102	103.33	103	103.33	108.67
30/10/23	1	104	100	102	101	99	102
	2	105	98	99	100	96	110
	3	102	101	106	100	92	100
	Average	103.67	99.67	102.33	100.33	95.67	104
31/10/23	1	97	100	101	93	94	96
	2	95	101	99	91	94	96
	3	95	97	99	92	95	98
	Average	95.67	99.33	99.67	92	94.33	96.67
01/11/23	1	111	105	115	100	101	100
	2	107	104	106	98	102	97
	3	107	103	103	95	99	100
	Average	108.33	104	108	97.67	100.67	99
03/11/23	1	99	96	97	89	90	97
	2	98	96	102	91	93	94
	3	96	98	105	91	92	93
	Average	97.67	96.67	101.33	90.33	91.67	94.67
06/11/23	1	105	98	108	100	98	103
	2	102	96	102	104	100	105
	3	97	97	105	101	99	101
	Average	101.33	97	105	101.67	99	103
07/11/23	1	94	97	97	99	96	96
	2	95	96	104	98	95	107

	3	90	95	98	98	96	98
	Average	93	96	99.67	98.33	95.67	100.33
08/11/23	1	99	112	104	98	98	98
	2	102	112	106	102	104	99
	3	96	106	102	97	99	101
	Average	99	110	104	99	100.33	99.33

Diastolic Pressure							
		Day time (9:00 AM to 10:00AM)			Evening Time (4:00 PM to 5:00PM)		
Date	Reading	Sitting	Supine	Standing	Sitting	Supine	Standing
25/10/23	1	69	65	71	68	68	76
	2	72	69	76	68	68	74
	3	71	72	74	64	65	73
	Average	70.67	68.67	73.67	66.67	67	74.33
27/10/23	1	69	62	71	70	67	74
	2	65	64	71	71	68	76
	3	64	65	65	71	63	80
	Average	66	63.67	69	70.67	66	76.67
30/10/23	1	66	65	65	67	61	71
	2	64	66	70	70	63	72
	3	66	67	73	68	62	61
	Average	65.33	66	69.33	68.33	62	68
31/10/23	1	62	62	67	62	61	69
	2	62	63	66	74	61	73
	3	64	62	71	65	64	71
	Average	62.67	62.33	68	67	62	71
01/11/23	1	73	65	71	64	69	71
	2	72	65	68	68	67	70
	3	67	63	69	67	67	71
	Average	70.67	64.33	69.33	66.33	67.67	70.67
03/11/23	1	64	62	73	64	62	66
	2	63	67	68	61	64	67
	3	64	66	70	61	67	68
	Average	63.67	65	70.33	62	64.33	67
06/11/23	1	64	62	66	71	67	75
	2	62	63	72	65	67	75

	3	64	62	72	68	69	72
	Average	63.33	62.33	70	68	67.67	74
07/11/23	1	62	62	70	69	64	68
	2	62	64	69	66	64	74
	3	70	60	70	63	61	75
	Average	64.67	62	69.67	66	63	72.33
08/11/23	1	68	72	72	72	70	70
	2	65	71	73	70	69	70
	3	70	69	72	70	71	69
	Average	67.67	70.67	72.33	70.67	70	69.67

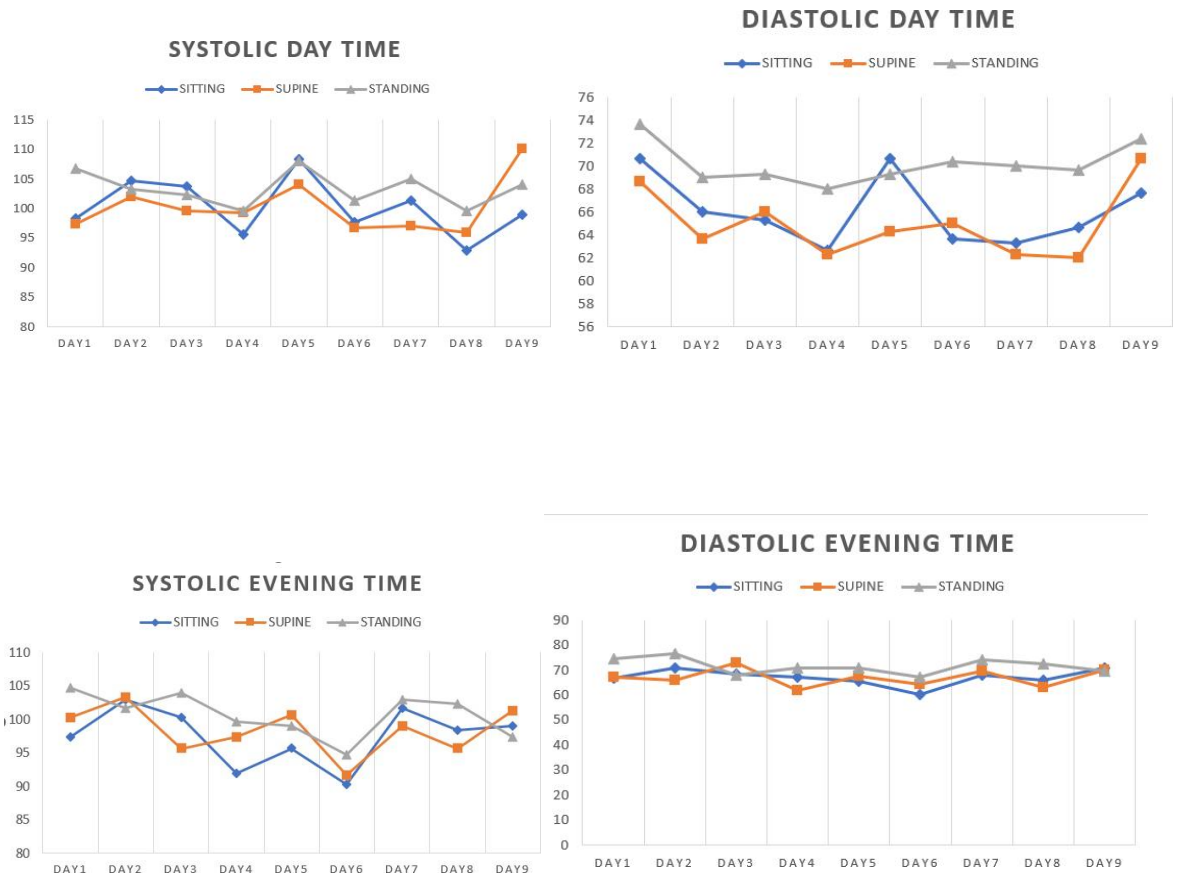


Fig 4. Plot for different position for BP Measurement during (a) Day Time and (b) Evening Time

Observation

- It is observed that the systolic and diastolic blood pressure is the highest in supine position compared the other positions.
- From the result it is also visible that blood pressure tends to drop in the standing position compared with the sitting and supine.
- Effect of daytime and evening time is also seen in experiment. In evening blood pressure seems to drop.

Conclusion

Blood pressure is critical indicator for cardiovascular, renal and other diseases. It is essential to consider the patient position and time while assessing the blood pressure. Patient position and time of measurement affects the BP measurements.

ELECTRICAL SAFETY TEST

AIM

To test electrical safety of patient monitor according to IEC 60601-1 electrical safety standard.

OBJECTIVE

To perform electrical safety test for electrical medical devices such as patient monitor

To develop an understanding of globally recognized electrical safety standards such as IEC 60601.

APPARATUS REQUIRED

The Fluke Biomedical ESA615 Electrical Safety Analyzer (the Product) is a full-featured compact, portable analyser, designed to verify the electrical safety of medical devices. The Product does these tests:

- Line (Mains) voltage
- Ground Wire (Protective Earth) resistance
- Equipment current
- Insulation resistance
- Ground (Earth) leakage
- Chassis (Enclosure) leakage
- Lead to Ground (Patient) and Lead to Lead (Patient Auxiliary) leakage
- Lead isolation (Mains on applied parts leakage)
- Differential leakage
- Direct equipment leakage
- Direct applied part leakage
- Alternative equipment leakage
- Alternative applied part patient leakage
- Point to point leakage, voltage, and resistance
- ECG simulation and performance waveforms

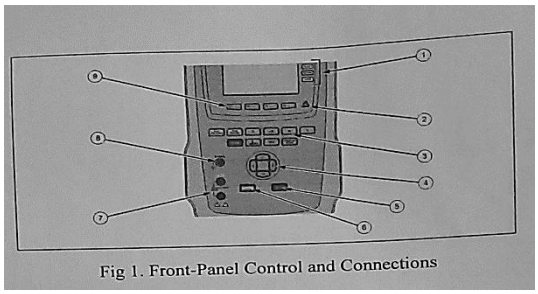


Fig 1. Front-Panel Control and Connections

Item	Name	Description
1	Equipment Outlet Configuration Buttons	Controls the configuration of the equipment outlet, Open, closes the neural and ground connection, and reverses the polarity of the neutral and hot connection.
2	High Voltage Indicator	Illuminates when high voltage is applied to the ECG/Applied Parts posts or L1 and L2 of the Test Receptacle,
3	Test Function Buttons	Selects the Product test functions
4	Navigation Buttons	Cursor control buttons for navigating menus and list.
5	Test Button	Starts selected tests.
6	Enter Button	Sets the highlighted function.
7	Input Jacks	Test lead connectors.
8	Nulling Jack	Connection to zero test lead resistance.
9	Function Softkeys	Keys F1 through F4 are used to select from a number of selections that show in the LCD display above each function softkey.

Item	Name	Description
1	Equipment Outlet	Equipment outlet, specified to the version of the product, which supplies a DUT connection.
2	USB A Controller Port	For external keyboard or barcode reader.
3	USB Device Port (Mini B-style connector)	Digital connection to control the Product from a PC or instrument controller.
4	Fuse Access Door	Equipment outlet fuse access.
5	Tilt Stand	Holds the Product in a tilted position.
6	SD Card Slot	SD Memory Card access.
7	AC Power Switch	Turns ac power on and off.

8	Power Input Connector	A grounded male three-prong (IEC 60320 C19) connector that accepts the line-power cord.
9	ECG/Applied Parts Jacks	Connection posts for Device under Test (DUT) applied parts, such as ECG leads. Used to test for leakage current through leads and to supply ECG signals and performance waveforms to a DUT.
10	Banana Jack to ECG Adaptor	Adapter to connect ECG snap lead to the product.

Fig 4. Side and Top-Panel Connections.

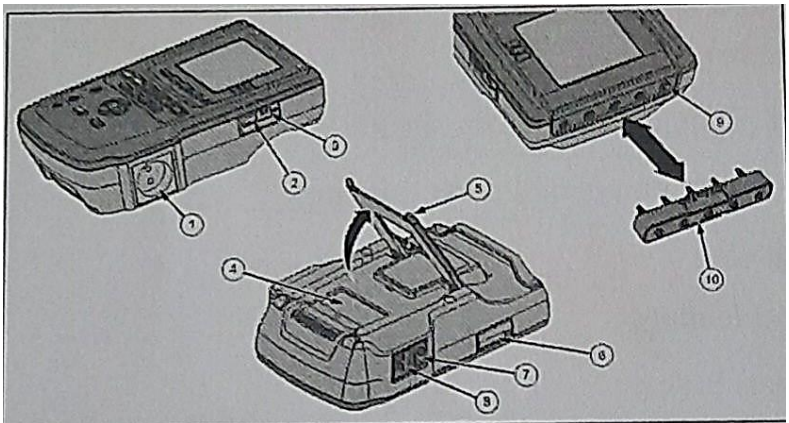


Fig 3. Side and Top-Panel Connections

PATIENT MONITOR

Patient monitors are devices used to measure, record, and display various patient parameters Much as heart rate and rhythm, SPO2, blood pressure, temperature, respiratory rate, blood pressure, blood oxygen saturation, etc, to keep a track of the patient's health and provide them with high-quality health care. Patient monitors are most often used in hospitals but are also frequently found in the homes of patients who suffer from a chronic illness, diabetes, etc., in order to keep an eye on their vitals and to detect further complications.

Nihon Kohden Vismo PVM-2703 is a 10-inch bedside patient monitor with high accuracy and simple operation. It measures seven parameters: ECG (3 or 6 electrodes), SpO2, NIBP, Impedance respiration, and temperature, IBP or CO2.

METHOD

- How to Connect a DUT to the Product-
- Figure 5 shows a Device Under Test (DUT) connected to the test receptacle, applied parts posts, and a connection to the enclosure or protective earth ground of the DUT.
- How to Turn On the Product-
- Push the power switch found on the left-side panel so the "I" side of the ac power switch is down. The Product does a series of self-tests and then shows a message when the self-tests and then shows a message when the self-test has completed successfully.
- How to Access the Product Functions.
- For each test and setup function, the Product uses a series of menus to access different Product tests and setup variables. The More softkey lets you access more menus related to the test. When you push a softkey (F1 through F4) below a test name, the Product sets up for or does the selected test.
- How to Set Up the Product.
- There are a number of Product parameters that are adjusted through the setup function. To access the first Setup menu, push SETUP. Set the Operator Name, Date, Time, and Test Standard (IEC 60601-1),
- Ground wire resistance test- Follow instructions on the screen and zero the test lead. .
- Connect the test lead back to the DUT and begin the test.
- Once the test has ended, results are stored in a SD Card and can be viewed in a computer later.

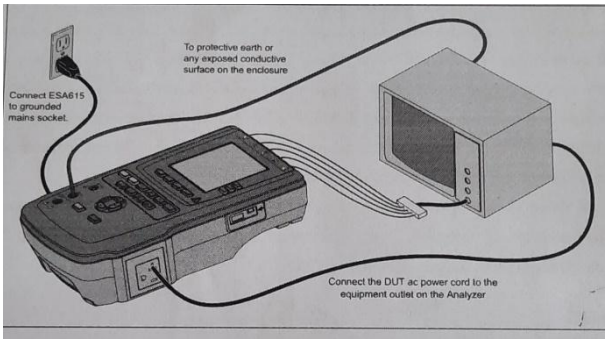
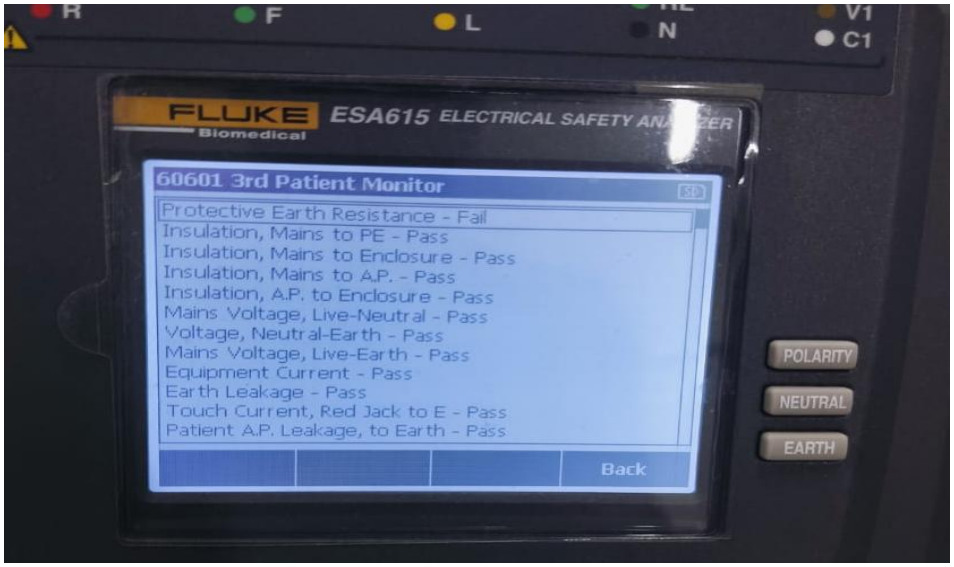


Fig 5. DUT Connections to the Product

OTHER STANDARDS FOR EQUIPMENTS

Standard	Description	Most Current Version
ISO 13485	Medical Device Quality Management Systems	ISO 13485:2016
ISO 14971	Medical Device Risk Management	ISO 14971:2019
ISO 9001	Business Quality Management Systems	ISO 9001:2015
ISO 62304	Software for Medical Devices	ISO 62304:2006
ISO 10993	Biological Evaluation of Medical Devices (23 Parts)	Various Parts
ISO 15223	Symbols for Medical Device Labels and Information	Two Parts
ISO 11135	Ethylene Oxide Sterilization of Medical Devices	ISO 11135:2014
ISO 11137	Sterilization of Medical Devices Using Radiation	Various Parts
ISO 11607	Sterilized Product Packaging for Medical Devices	Various Parts
IEC 60601	Safety and Performance of Medical Electrical Equipment	Country-specific versions

OBSERVATION



CONCLUSION

- The device under test either passed or failed the electrical safety test.
- The device can be said to comply to the recognized electrical safety standards for medical devices, such as IEC 60601-1.

MEASUREMENT OF THE SPATIAL VARIATION OF PLANTAR TISSUE VISCOELASTICITY IN NORMAL SUBJECTS

Aim

To measure plantar tissue viscoelasticity from anatomical locations of interest using myotonometry and shore durometer.

Objective

- To identify and mark the anatomical locations on the plantar aspect
- To record myotonometric parameters from the plantar anatomic sites
- To measure hardness of the plantar anatomic sites using shoremeter
- To compare the shore hardness and myotonometric parameters
- To analyse the spatial variation of plantar viscoelastic measurements

Apparatus Required

- Myotonometer
- Shore Durometer
- MATLAB

Theory

Plantar soft tissues have an inhomogeneous collagen-rich architecture with inclusions of fat globules. The compliance of the plantar soft tissue allows the dissipation of the ground impact loads on the foot during ambulation. Thus, it provides a cushioning effect against the plantar pressure loads during daily movements which protects the deep tissue structures from stress- induced damage.

The cushioning effect of plantar is dependent on the viscoelastic properties of the plantar tissues. Measurement of plantar tissue viscoelasticity has been predominantly done using manual palpation in the clinical practice hitherto. However, quantification of mechanical properties of plantar tissue for reliable assessment of the state of the tissues. Static indentation technique is a direct way of measuring target tissue property, where the deformation of tissue against imposed load is taken as the measure of tissue stiffness. Shore durometer works in the principle of measuring the spring deformation in response to imposed load. Type A durometer is customary device for measuring rubber elastomer hardness, and it has been predominantly used in the field of the biomedical

domain. The measurements are made in terms of the hardness scale of 1 to 100, with increasing score indicating higher stiffness. The hardness score is directly proportional to Young's modulus of the material.

Myotonometry is, on the other hand, a dynamic indentation technique that measures the inertial oscillation of the tissue under input impulse load. In this technique, a 0.4 N impulse load is applied on the tissue using an automatic electromagnetic linear actuator for 15 ms. The resulting free oscillation is recorded using an accelerometer for the consequent 400 ms. The acceleration signal is further analysed to compute the myotonometric parameters such as Oscillation Frequency, Logarithmic Decrement, Dynamic Stiffness and Relaxation Time. Oscillation Frequency (OF) is the peak frequency of the oscillation determined from the power spectrum of the myonometry signal. Logarithmic Decrement (LOD) determines the order of decrement from the first to second positive peak and can be mathematically expressed as LoD=lna/root(a3). Dynamic Stiffness (DS) is the characteristic resistance of the tissue against any imposed deformation and can be estimated as DS=m.a1Δl where m is the mass of the probe. Relaxation Time (RT) is the measure of the time scale required for the deformed tissue to attain the original shape and is defined as

$$RT=tR-t$$

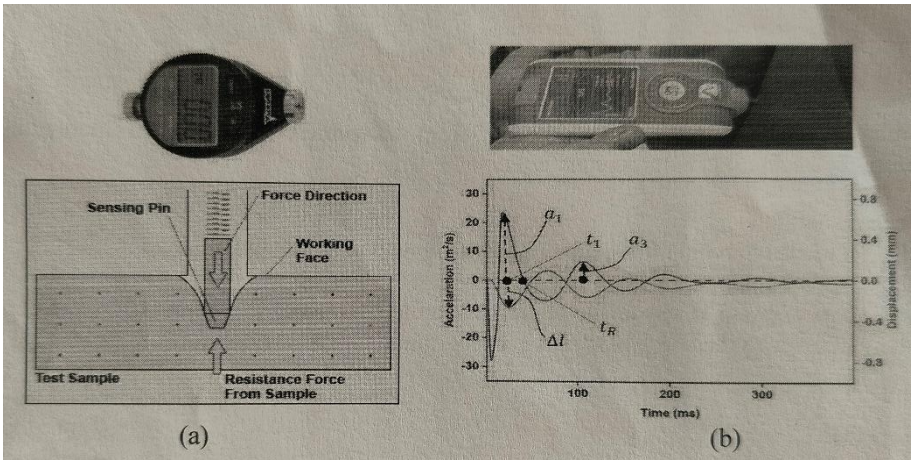
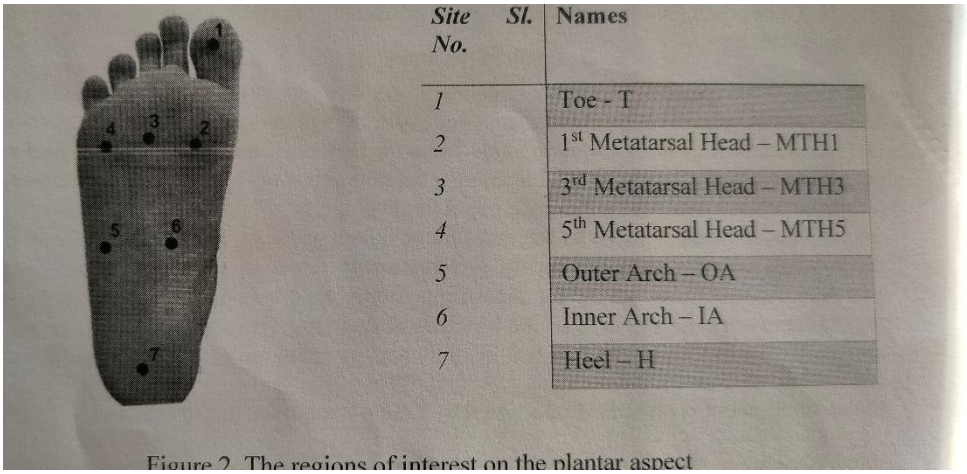


Figure 1. Working principles of the (a) Shore Durometer and (b) Myotonometer



Site No.	Sl.	Names
1		Toe - T
2		1st Metatarsal Head – MTH1
3		3rd Metatarsal Head – MTH3
4		5th Metatarsal Head – MTH5
5		Outer Arch – OA
6		Inner Arch – IA
7		Heel – H

Figure 2. The regions of interest on the plantar aspect

The methodology of the experiment is as follows

1. 15 minutes of rest is provided for the subjects before the experiment commences
2. The plantar aspect is cleaned with a wet cloth and the seven anatomical sites are marked for the reference of measurements.
3. The hardness of the anatomical sites is recorded using Shore Durometer
4. The myotonometric parameters are also consequently recorded from all the seven anatomical sites
5. The choice of order for the foot is randomized, but nevertheless, measurements is to be carried out from both right and left feet.

Table 1. Spatial distribution of the mechanical properties of the plantar soft tissue measured by the myotonometer and the durometer.

Foot	Site	Myotonometer				Duromter
		OF (Hz)	LoD	DS (N/m)	RT (ms)	HA
Right	T	24	2.94	486	9.8	14.5
	MTH1	23.3	1.59	458	11.2	18.5
	MTH3	27.4	1.41	551	9.6	15.5
	MTH5	28.1	1.52	524	9.4	18

	OA	31.5	1.96	701	6.9	27
	IA	27.7	1.55	638	8.6	21.5
	H	30.3	1.71	658	7.6	23.5
Left	T	29.5	2.9	492	9.3	13.5
	MTH1	28.9	1.83	561	9.7	17
	MTH3	31	1.52	630	8.4	15
	MTH5	26.1	2.22	517	9.5	15
	OA	30.4	1.31	663	7.3	24
	IA	26.2	1.72	607	9.3	19
	H	39.1	1.87	932	4.7	24.5

PYTHON CODE FOR PLOTTING THE GRAPH

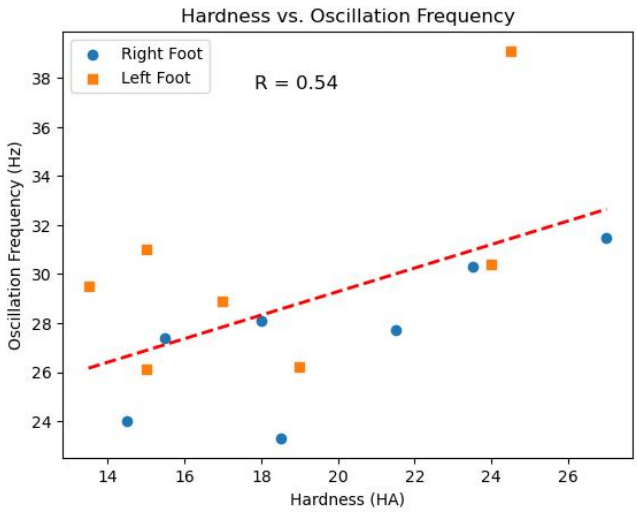
```
import numpy as np
import matplotlib.pyplot as plt

# Defining the parameters for the right foot
hardness_right = [14.5, 18.5, 15.5, 18, 27, 21.5, 23.5];
oscillation_freq_right = [24, 23.3, 27.4, 28.1, 31.5, 27.7, 30.3];
Dynamic_stiffness_right = [486, 458, 551, 524, 701, 638, 658];
Log_decrement_right = [2.94, 1.59, 1.41, 1.52, 1.96, 1.55, 1.71];
Relapse_time_right = [9.8, 11.2, 9.6, 9.4, 6.9, 8.6, 7.6];
#defining the parameters for right foot
hardness_left = [13.5,17,15,15,24,19,24.5];
oscillation_freq_left = [29.5,28.9,31,26.1,30.4,26.2,39.1];
Dynamic_stiffness_left = [492,561,630,517,663,607,932];
Log_decrement_left = [2.96,1.83,1.52,2.22,1.91,1.72,1.87];
```

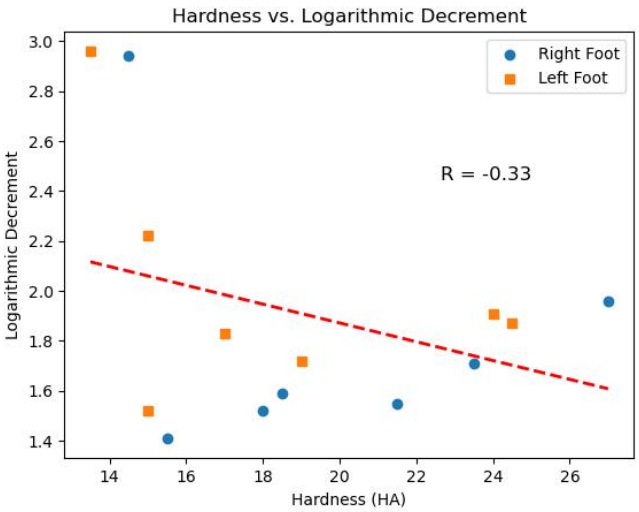
```
Relapse_time_left = [9.3,9.7,8.4,9.5,7.3,9.3,4.7];

# Combine data for both feet
hardness = np.concatenate((hardness_right, hardness_left))
oscillation_freq = np.concatenate((oscillation_freq_right, oscillation_freq_left))
Log_decrement = np.concatenate((Log_decrement_right, Log_decrement_left))
Relapse_time = np.concatenate((Relapse_time_right, Relapse_time_left))
Dynamic_stiffness=np.concatenate((Dynamic_stiffness_right,Dynamic_stiffnes
s_left))

# Scatter plot with different markers
plt.figure(1)
plt.scatter(hardness[:7], oscillation_freq[:7], marker='o', label='Right Foot')
plt.scatter(hardness[7:], oscillation_freq[7:], marker='s', label='Left Foot')
plt.title('Hardness vs. Oscillation Frequency')
plt.xlabel('Hardness (HA)')
plt.ylabel('Oscillation Frequency (Hz)')
plt.legend()

# Calculate and plot regression lines
coeffs = np.polyfit(hardness, oscillation_freq, 1)
x_fit = np.linspace(min(hardness), max(hardness), 100)
y_fit = np.polyval(coeffs, x_fit)
plt.plot(x_fit, y_fit, 'r--', linewidth=2)

# Calculate Pearson correlation coefficient
R_value_HoF = np.corrcoef(hardness, oscillation_freq)[0, 1]
```

```
# After plotting your data points, add the R value to the graph:
# Add the R value to the top of the graph
plt.text(20, max(oscillation_freq) - 1, f'R = {R_value_HoF:.2f}', fontsize=12, ha='right', va='top')
plt.show()
# Scatter plot for Hardness vs. Logarithmic Decrement
plt.figure(2)
plt.scatter(hardness[:7], Log_decrement[:7], marker='o', label='Right Foot')
plt.scatter(hardness[7:], Log_decrement[7:], marker='s', label='Left Foot')
plt.title('Hardness vs. Logarithmic Decrement')
plt.xlabel('Hardness (HA)')
plt.ylabel('Logarithmic Decrement')
plt.legend()

# Calculate and plot regression lines
coeffs = np.polyfit(hardness, Log_decrement, 1)
x_fit = np.linspace(min(hardness), max(hardness), 100)
y_fit = np.polyval(coeffs, x_fit)
plt.plot(x_fit, y_fit, 'r--', linewidth=2)

# Calculate Pearson correlation coefficient
R_value_HLD = np.corrcoef(hardness, Log_decrement)[0, 1]

# Add the R value to the graph (right side)
plt.text(25, 2.5, f'R = {R_value_HLD:.2f}', fontsize=12, ha='right', va='top')
plt.show()

# Scatter plot for Hardness vs. Dynamic Stiffness
```

```
plt.figure(3)
plt.scatter(hardness[:7], Dynamic_stiffness[:7], marker='o', label='Right Foot')
plt.scatter(hardness[7:], Dynamic_stiffness[7:], marker='s', label='Left Foot')
plt.title('Hardness vs. Dynamic Stiffness')
plt.xlabel('Hardness (HA)')
plt.ylabel('Dynamic Stiffness (N/m)')
plt.legend()

# Calculate and plot regression lines
coeffs = np.polyfit(hardness, Dynamic_stiffness, 1)
x_fit = np.linspace(min(hardness), max(hardness), 100)
y_fit = np.polyval(coeffs, x_fit)
plt.plot(x_fit, y_fit, 'r--', linewidth=2)

# Calculate Pearson correlation coefficient
R_value_HDS = np.corrcoef(hardness, Dynamic_stiffness)[0, 1]

# Add the R value to the graph (right side)
plt.text(25, 950, f'R = {R_value_HDS:.2f}', fontsize=12, ha='right', va='top')
plt.show()

# Scatter plot for Hardness vs. Relapse Time
plt.figure(4)
plt.scatter(hardness[:7], Relapse_time[:7], marker='o', label='Right Foot')
plt.scatter(hardness[7:], Relapse_time[7:], marker='s', label='Left Foot')
plt.title('Hardness vs. Relaxation Time')
plt.xlabel('Hardness (HA)')
```

```
plt.ylabel('Relaxation Time (ms)')
plt.legend()

# Calculate and plot regression lines
coeffs = np.polyfit(hardness, Relapse_time, 1)
x_fit = np.linspace(min(hardness), max(hardness), 100)
y_fit = np.polyval(coeffs, x_fit)
plt.plot(x_fit, y_fit, 'r--', linewidth=2)

# Calculate Pearson correlation coefficient
R_value_HRT = np.corrcoef(hardness, Relapse_time)[0, 1]

# Add the R value to the graph (right side)
plt.text(25, 10, f'R = {R_value_HRT:.2f}', fontsize=12, ha='right', va='top')
plt.show()
```





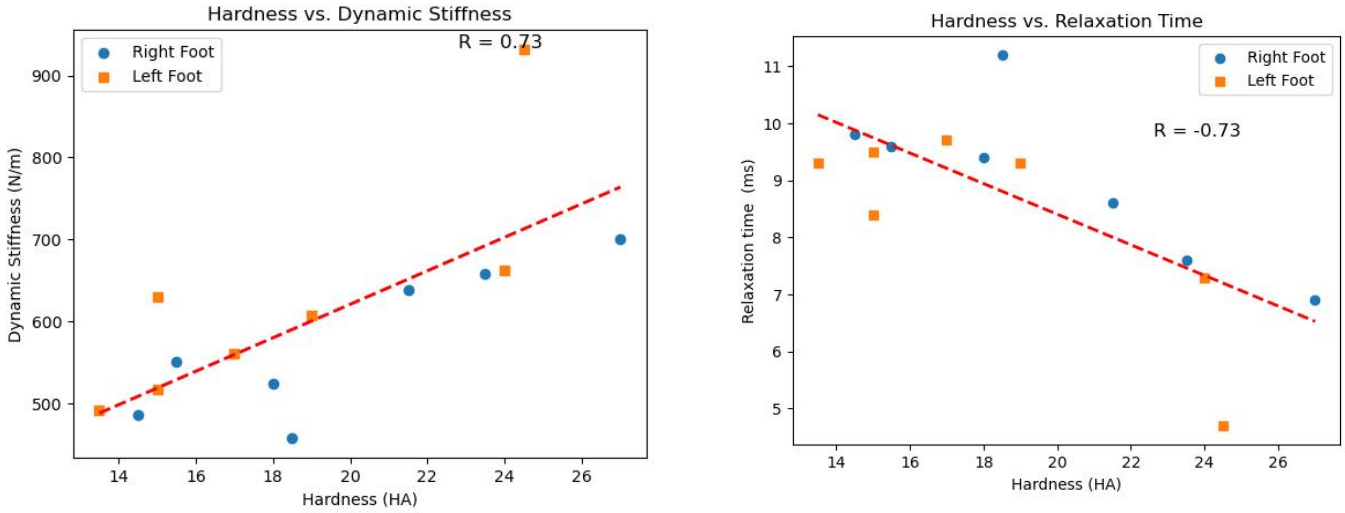


Figure 3. Variation of the myotonometric parameters with the hardness measurements using Shore Durometer (a) Oscillation Frequency, (b) Logarithmic Decrement, (c) Dynamic Stiffness, and (d) Relaxation Time.

RESULT

The highest correlation is for the Hardness vs dynamic stiffness = 0.73

CONCLUSION

Plantar tissue mechanical properties vary spatially, with different tissue properties in the forefoot, midfoot, and hindfoot region. The measurements from different techniques to characterize tissue properties are comparable to each other.

RECORDING AND ANALYSIS OF SURFACE EMG SIGNALS WITH VARRYING GRIP STRENGTH

AIM

To record and analyse EMG signals from flexor muscle with varying grip strength to identify variations in dominant and non-dominant hand.

OBJECTIVES

- To record EMG signals using signal acquisition system with minimum artifacts
- To identify correlation in EMG signals with varying grip strength for dominant and non-dominant hands.

APPARATUS REQUIRED

- Ag-AgCl foam disc-type surface electrodes
- Gauze for skin preparation
- Computer
- Hand dynamometer (kg).
- Biopac Science Lab system (MP40 and software)
- MATLAB SOFTWARE

THEORY

Skeletal muscles are responsible for numerous activities that are performed in our daily life such as locomotion and posture maintenance. They play a vital role in force control for making precise or powerful movements. It consists of fibres that are innervated by a-motor neurons for producing these movements. Surface electromyography (SEMG) is a non-invasive technique that records muscle activity with the help of surface electrodes. Measurement of maximal grip strength (MGS) is an essential element to follow people during growth, ageing, injury, rehabilitation, training or therapeutic trials. Its measurement is performed using dynamometers, which estimate the muscle strength primarily generated by the flexor muscles of the hand and the forearm.

METHOD

EMG electrode placement

The signals are attained from the participants' dominant hand. The criteria for the selection of subjects include no experience in weight training and no neuromuscular disease history. An informed consent of the subject is taken, since pain may be induced during the exercise which might last for a few days. Before recording the signal, the skin is abraded and cleaned in order to provide better electrode skin interface. The alcohol is widely used for cleaning the skin

in order to eliminate the wetness or sweat and reduce skin impedance. Instructions about the task are provided to subjects prior to start of the experimentation. The signals are acquired in bipolar electrode configuration with two surface electrodes kept on flexor muscle belly at an interelectrode distance of 2 cm based on Surface Electromyography for Non Invasive Assessment of Muscles (SENIAM) standards.

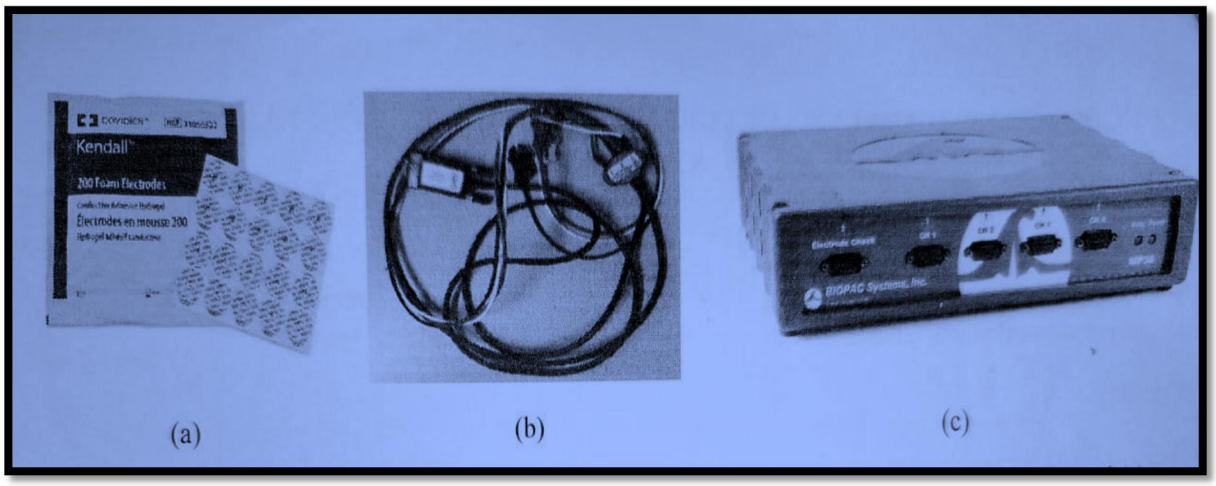


Fig. 1. Signal acquisition (a) Ag-AgCl Surface electrodes (b) Shielded cables and (c) BIOPAC bioamplifier system.

sEMG SIGNAL ACQUSITION

The participants are advised to stand straight on the insulated platform to isolate from the ground. The sEMG signals are acquired with BIOPAC MP36 data acquisition system which is approved by Food and Drug Administration. The bioamplifier has signal to noise ratio, differential mode input impedance and common mode rejection ratio of 89 dB, 2 MS2 and 110 dB respectively. The 24 bits resolution analog to digital converter is present in the acquisition system and the gain is set to 1000. The signals are acquired with the sampling rate of 10 KHz. In the offline analysis, the signal is down sampled to 1000 Hz, in order to reduce the computational head.

HAND GRIP STRENGTH MEASUREMENT

The height and weight of the subjects were recorded as well as anthropometric hand data were measured by the experimenter using a standard 1000-mm tape measure. The circumference of the forearm was defined as the perimeter of the largest part of the forearm, located over the bulk of the brachioradialis muscle, at the proximal quarter of the whole forearm length (Fig. 2a). The circumference of the hand was measured as the perimeter of the middle part of hand, located at the two major transverse palmar creases ("heart line" and "head line") (Fig. 2b). Hand length was defined as the distance from the tip of the middle finger to the midline of the distal wrist crease (Fig. 2c). All

anthropometric data were measured to the nearest millimetre with the forearm and hand in an outstretched and supinated position. Dominant side was defined as the hand with which the subject writes.

EXPERIMENTAL SETUP

- Before applying electrodes to the subject, it is first important to properly prepare and clean the electrode sites
- Let the areas dry before attaching the electrodes
- Two surface electrodes kept on flexor muscle belly at an interelectrode distance of 2 cm
- A reference electrode is positioned in the elbow
- Setup the Biopac signal acquisition system. Insert the connectors on the red and black electrode lead wires into the matching sockets on the EMG cable
- The subjects are instructed to maintain an upright posture with the minimal torso and the upper arm distance. They are advised not to rest the elbow on the hip
- The upper arm is maintained in vertical position and the forearm is held in supine position.
- Subjects were verbally encouraged to produce their maximal grip strength (MGS). Two trials were first recorded, consisting of a 2-4-second maximal contraction, with a 30-second rest period between each trial. If the relative difference between these two MGS was within 10%, no additional trial was required.
- This is repeated for 50% and 10% MGS in stages, noting down the values of dynamometer.
- Raw signals are pre-processed and analysed using MATLAB.

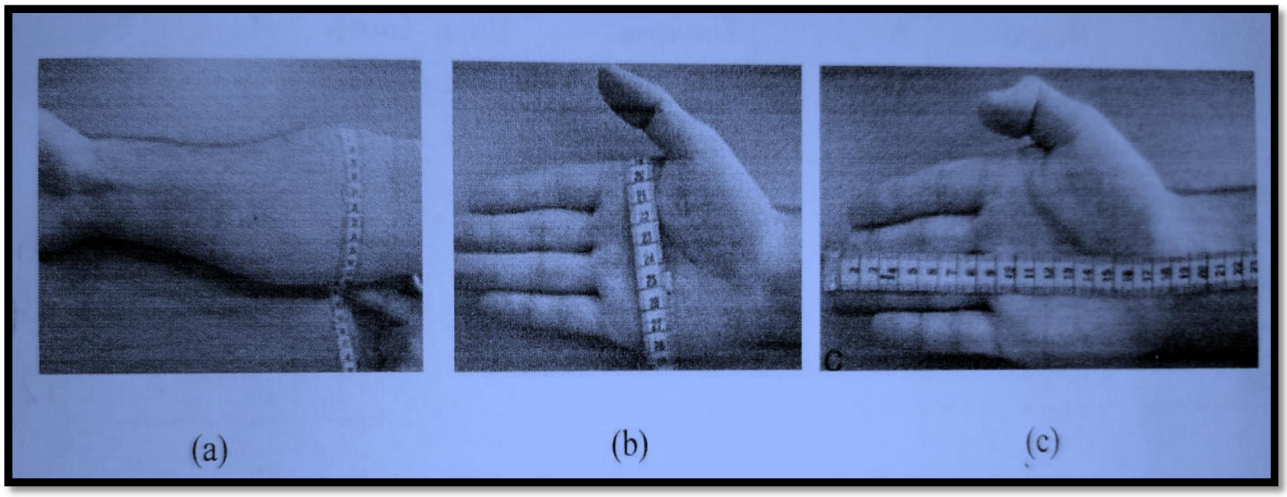


Fig. 2. Measurements of anthropometric characteristics of hand and forearm including (a) forearm circumference. (b) hand circumference and (c) hand length.

PLACEMENT OF ELECTRODES FOR RECORDING EMG

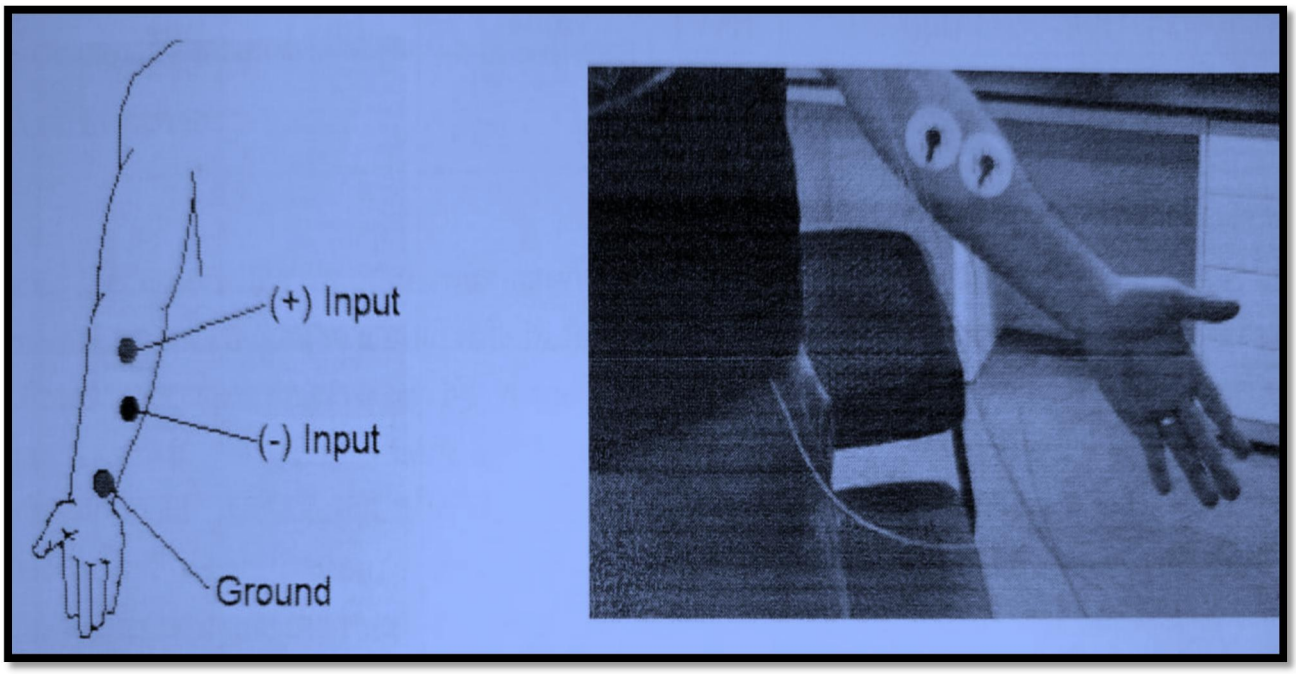


TABLE 1: ANTHROPOMETRIC MEASUREMENTS

Subject	Height(c	Weight(l	Upper Forearm Circumference (cm)	Lower forearn Circumferenc (cm)	Hand Length (cm)
Dominant Hand	-	-	26.1	17.6	31
Non-Dominant Hand	-	-	25	16.1	31

MATLAB CODE:

```
% Load the EMG signal from the .mat file
emg_signal=load("F:\IITM\Physiological measurements lab\EMG data\KaviDom.mat"); % Replace 'your_emg_data.mat' with the actual filename
my_data=emg_signal.data;
% Plot the original EMG signal
figure;
plot(my_data);
title('Original EMG Signal');
xlabel('Sample Number');
ylabel('Amplitude');
```

```
grid on;
%separating the peaks based on activity for grip strength
force_max=my_data(28356:38695);%maximum grip stength
force_50=my_data(39000:48000);%50% of maximum grip strength
force_10=my_data(48000:57077);%10% of maximum grip strength
%for maximum grip strength
%RMS Vaue
rms_value_max = rms(force_max);
disp(['RMS Value for maximum grip strength for dominant hand: ',
num2str(rms_value_max)]);
%Mean absolute value
mav_value_max = mean(abs(force_max));
disp(['Mean Absolute Value (MAV) for maximum grip strength for dominant
hand: ', num2str(mav_value_max)]);
%Max amplitude
max_amplitude_max = max(abs(force_max));
disp(['Maximum Amplitude for maximum grip strength for dominant hand: ',
num2str(max_amplitude_max)]);

%Zero crossing rate
zero_crossings_max = sum(abs(diff(sign(force_max))) > 0);
zero_crossing_rate_max = zero_crossings_max / (length(force_max) - 1);
disp(['Zero-Crossing Rate for maximum grip strength for dominant hand:: ',
num2str(zero_crossing_rate_max)]);
```

```
%for 50 % of Maximum grip strength

%RMS Vaue
rms_value_50= rms(force_50);
disp(['RMS Value for 50 % of maximum grip strength for dominant hand: ',
num2str(rms_value_50)]);
%Mean absolute value
mav_value_50= mean(abs(force_50));
disp(['Mean Absolute Value (MAV) for 50 % of maximum grip strength for
dominant hand: ', num2str(mav_value_50)]);
%Max amplitude
max_amplitude_50 = max(abs(force_50));
disp(['Maximum Amplitude for 50 % of maximum grip strength for dominant
hand: ', num2str(max_amplitude_50)]);
%Zero crossing rate
zero_crossings_50 = sum(abs(diff(sign(force_50))) > 0);
zero_crossing_rate_50 = zero_crossings_50 / (length(force_50) - 1);
```

```
disp(['Zero-Crossing Rate for 50 % of maximum grip strength for dominant hand:: ', num2str(zero_crossing_rate_50)]);


%for 10 % of Maximum grip strength
%RMS Vaue
rms_value_10= rms(force_10);
disp(['RMS Value for 10 % of maximum grip strength for dominant hand: ', num2str(rms_value_10)]);
%Mean absolute value
mav_value_10= mean(abs(force_10));
disp(['Mean Absolute Value (MAV) for 10 % of maximum grip strength for dominant hand: ', num2str(mav_value_10)]);
%Max amplitude
max_amplitude_10 = max(abs(force_10));
disp(['Maximum Amplitude for 10 % of maximum grip strength for dominant hand: ', num2str(max_amplitude_10)]);
%Zero crossing rate
zero_crossings_10 = sum(abs(diff(sign(force_10))) > 0);
zero_crossing_rate_10 = zero_crossings_10 / (length(force_10) - 1);
disp(['Zero-Crossing Rate for 10 % of maximum grip strength for dominant hand:: ', num2str(zero_crossing_rate_10)]);
% Sample EMG signal and time vector (replace with your actual data)
fs = 1000; % Sampling frequency in Hz
% Calculate the RMS of the EMG signal in a sliding manner
windowSize = 100; % Choose an appropriate window size
rmsValues_max = zeros(1, length(force_max) - windowSize + 1);

for i = 1:length(rmsValues_max)
    rmsValues_max(i) = rms(force_max(i:i+windowSize-1));
end
% Create a time vector for RMS values
timeRMS_max = (0:length(rmsValues_max)-1) / fs;

%for 50% force
rmsValues_50 = zeros(1, length(force_50) - windowSize + 1);

for i = 1:length(rmsValues_50)
    rmsValues_50(i) = rms(force_50(i:i+windowSize-1));
end

% Create a time vector for RMS values
timeRMS_50 = (0:length(rmsValues_50)-1) / fs;
```

```
%for 10% force
rmsValues_10 = zeros(1, length(force_10) - windowSize + 1);

for i = 1:length(rmsValues_10)
    rmsValues_10(i) = rms(force_10(i:i+windowSize-1));
end

% Create a time vector for RMS values
timeRMS_10 = (0:length(rmsValues_10)-1) / fs;

% Plot the RMS values with respect to time
figure;
subplot(3,2,1);
plot(force_max);
xlabel('Time (ms)');
ylabel('EMG Signal(mV)');
title('EMG Signal Over Time for maximum grip strength');
subplot(3,2,2);
plot(timeRMS_max, rmsValues_max);
xlabel('Time (s)');
ylabel('RMS of EMG Signal (mV)');
title('RMS of EMG Signal Over Time for maximum grip strength');
subplot(3,2,3);
plot(force_50);
xlabel('Time (ms)');
ylabel('EMG Signal(mV)');
title('EMG Signal Over Time for 50 % of maximum grip strength');
subplot(3,2,4);
plot(timeRMS_50, rmsValues_50);
xlabel('Time (s)');
ylabel('RMS of EMG Signal (mV)');
title('RMS of EMG Signal Over Time for 50 % of maximum grip strength');
subplot(3,2,5);
plot(force_10);
xlabel('Time (ms)');
ylabel('EMG Signal(mV)');
title('EMG Signal Over Time for 10 % of maximum grip strength');
subplot(3,2,6);
plot(timeRMS_10, rmsValues_10);
xlabel('Time (s)');
ylabel('RMS of EMG Signal (mV)');
title('RMS of EMG Signal Over Time for 10 % of maximum grip strength');
```

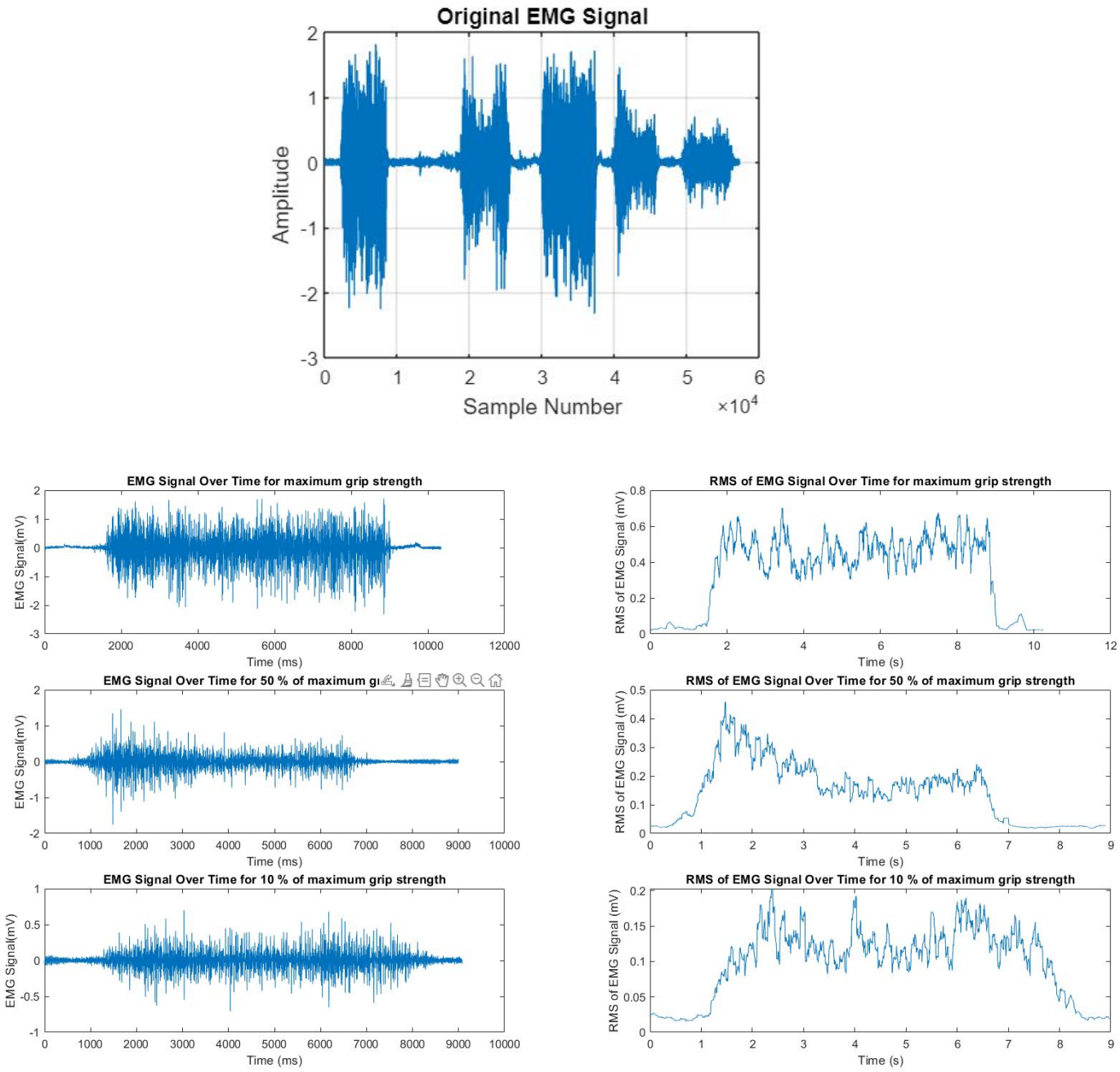


Figure 4: Representative of raw sEMG signals recorded and RMS of EMG Signal recorded for **Dominant Hand**

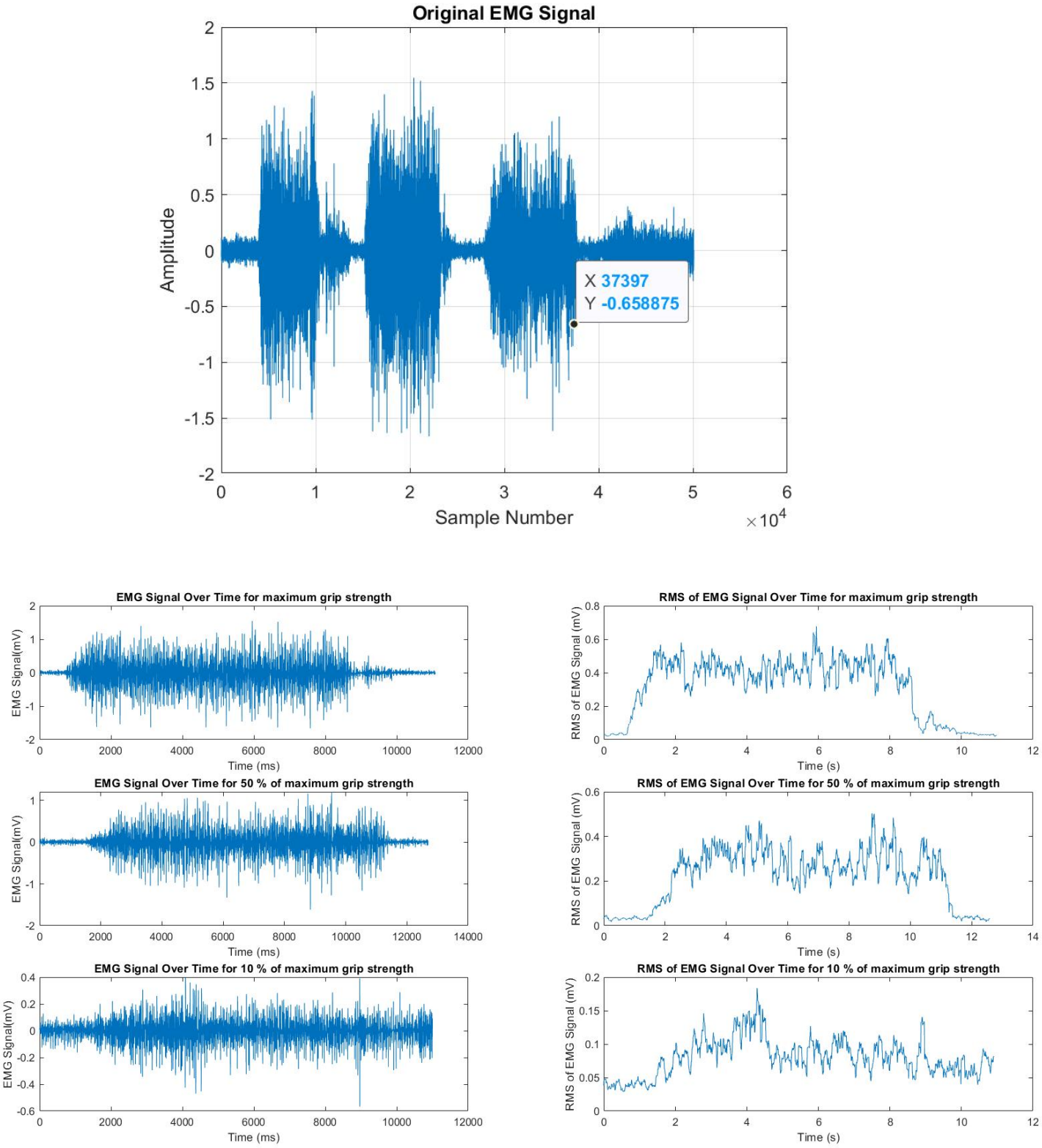


Figure 5: Representative of raw sEMG signals recorded and RMS of EMG Signal recorded for **Non-dominant Hand**

Result:

Subject	Grip Strength	Grip Strength (Kg)	RMS Value (mV)	Mean Absolute Value	Maximum Amplitude (mV)	Zero Crossing Rate
Dominant Hand	**Maximum (100%)**	63	0.40464	0.25495	2.3224	0.1889
Non-dominant Hand	**Maximum (100%)**	63	0.36058	0.24292	1.6641	0.14091
Dominant Hand	**50%**	31.5	0.17683	0.10626	1.756	0.21556
Non-dominant Hand	**50%**	31.5	0.25489	0.16944	1.6159	0.13507
Dominant Hand	**10%**	6.3	0.10941	0.070974	0.70984	0.21747
Non-dominant Hand	**10%**	6.3	0.084501	0.061312	0.56732	0.19389

Table 2: Observations Recorded

- From the table it is obvious that the RMS value and the mean absolute value decreases as the grip strength decreases.

CONCLUSION

Time domain features are extracted from the pre-processed EMG signals to identify variations in signals recorded from non-dominant hand of a subject with varying grip strength.

SEGMENTATION OF RETINAL BLOOD VESSELS FROM FUNDUS IMAGES USING MATLAB

AIM

To segment and validate the segmentation of retinal blood vessels from fundus images using

Image Processing and Computer Vision toolbox in MATLAB.

OBJECTIVE

To segment retinal blood vessels from fundus images using MATLAB

APPARATUS REQUIRED

- Laptop
- MATLAB software

THEORY

The separation of blood vessels in the retina is a major aspect of detecting ailment and is carried out by segregating the retinal blood vessels from the fundus images. The retina is a type of photosensitive tissue that lines the interior layer of the eye. Retinal blood vessels are a part of the central retinal artery, vein, and their branch. Any changes in these retinal vessels in terms of their morphology or topography are employed to identify some pathology such as diabetic retinopathy. Fundus cameras are most commonly used to obtain images of the retina. The images obtained by the fundus camera are known as fundus images. It contains not only the image of the retina but also some diagnostic information about the retina. To measure the alterations that occur in blood vessels, a blood vessel segmentation image has to be developed from the obtained fundus image. This is usually performed by expert medical practitioners manually. These limitations in retinal manual retinal segmentation such as inter-rater variability and error rates have led to development of automation in retinal segmentation. Analyzing the retinal image can hold a crucial role in identifying and classifying retinal diseases such as age- based macular degeneration, diabetic retinopathy (DR), retinoblastoma, macular bunker.

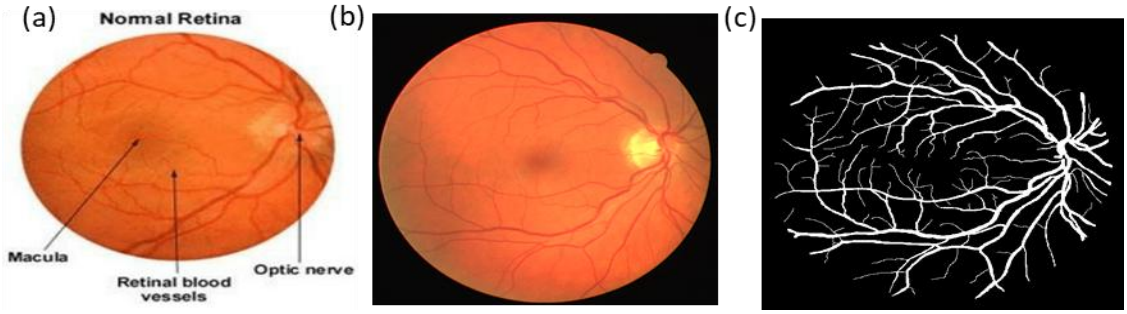


Fig 1. The images correspond to (a) Normal retina, (b) Fundus image. (c) Retinal vessels

METHOD

Download and install Image Processing and Computer Vision' toolbox, and launch MATLAB. Load the RGB fundus image and the ground truth image provided. Ground truth image refers to the image which contains the retinal vessels extracted by manual process. Convert the fundus image to grayscale image. The contrast enhancement is performed to enhance the image resulting in better segmentation followed by background noise removal and thresholding. The morphological process in MATLAB further cleans the obtained image. Generate the binary mask of the segmented region by the sequences provided. The performance of retinal segmentation methods is measured regarding segment pixels. So segmented pixels are differentiated for vessels and non-vessels or backgrounds. Validate the segmentation result using the Dice coefficient overlap measure and Jaccard index as follows:

$$\text{Dice coefficient} = 2*|Y \cap X|/|X|+|Y|$$
$$\text{Jaccard index} = |X \cap Y||Y \cup X|$$

where Y and X denote the segmented region and corresponding ground truth, respectively.

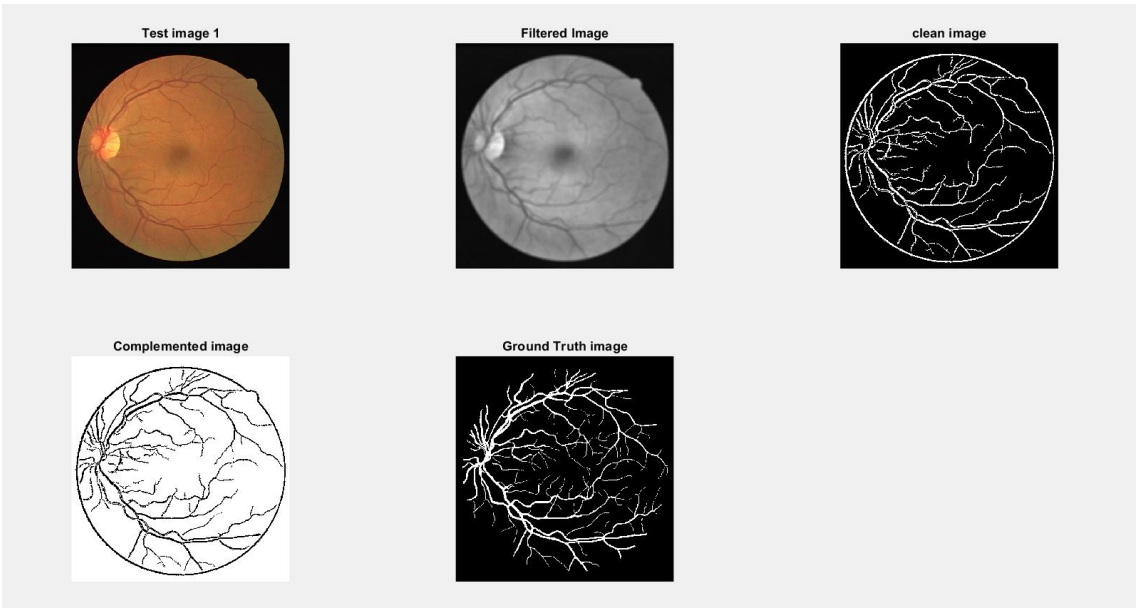
Repeat the same experiment for other images to extract retinal blood vessels.

MATLAB CODE:

```
Test_image=imread("F:\IITM\Physiological measurements
lab\images_retinal_seg\retina_images\1.tif");
GT= imread("F:\IITM\Physiological measurements
lab\images_retinal_seg\ground truth images\1.tif");

Resized_Image =imresize(Test_image,[584 565]);
```

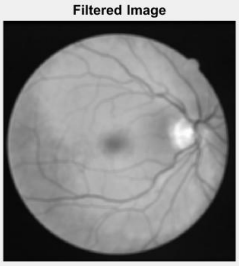
```
Converted_Image=im2double(Resized_Image);

Lab_Image=rgb2lab(Converted_Image);
fill=cat(3,1,0,0);
Filled_Image=bsxfun(@times,fill,Lab_Image);
Reshaped_Lab_Image=reshape(Filled_Image,[],3);

[C, S]=pca(Reshaped_Lab_Image);
S=reshape(S,size(Lab_Image));
S=S(:,:,1);
Gray_Image=(S-min(S(:)))./(max(S(:))-min(S(:)));

Enhanced_Image=adapthisteq(Gray_Image,'NumTiles',[8 8],'nbins',128);
Avg_Filter=fspecial('average',[9 9]);
Filtered_Image=imfilter(Enhanced_Image,Avg_Filter);

substracted_Image=imsubtract(Filtered_Image,Enhanced_Image);
level=Threshold_Level(substracted_Image);

figure,subplot(221),imshow(Test_image)
title('Test image 1')
subplot(222), imshow(Filtered_Image)
title('Filtered Image')
Binary_Image=imbinarize(substracted_Image,level-0.008);
subplot(223),imshow(Binary_Image)
title('Binary Image')
Clean_Image=bwareaopen(Binary_Image,50);
subplot(223),imshow(Clean_Image)
title('clean image')
Complemented_Image=imcomplement(Clean_Image);
subplot(224),imshow(Complemented_Image)
title('Complemented image')
%%
similarity = dice(im2double(Clean_Image),im2double(GT))
Jrrad=jaccard(im2double(Clean_Image),im2double(GT))


%%
function level=Threshold_Level(Image)

Image=im2uint8(Image(:));
[Histogram_count,Bin_Number]=imhist(Image);
i=1;
```

```
Cumulative_Sum = cumsum(Histogram_count);
T(i)=(sum(Bin_Number.*Histogram_count))/Cumulative_Sum(end);
T(i)=round(T(i));
Cumulative_Sum_2= cumsum(Histogram_count(1:T(i)));
MBT=sum(Bin_Number(1:T(i)).*Histogram_count(1:T(i)))/Cumulative_Sum_
2(end);
Cumulative_Sum_3= cumsum(Histogram_count(T(i):end));
MAT=sum(Bin_Number(T(i):end).*Histogram_count(T(i):end))/Cumulative_S
um_3(end);
i=i+1;
T(i)=round((MAT+MBT)/2);
while abs(T(i)-T(i-1))>=1

Cumulative_Sum_2= cumsum(Histogram_count(1:T(i)));
MBT=sum(Bin_Number(1:T(i)).*Histogram_count(1:T(i)))/Cumulative_Sum_
2(end);

Cumulative_Sum_3= cumsum(Histogram_count(T(i):end));
MAT=sum(Bin_Number(T(i):end).*Histogram_count(T(i):end))/Cumulative_S
um_3(end);

i=i+1;
T(i)=round((MAT+MBT)/2);
Threshold = T(i);
end
level=(Threshold-1)/(Bin_Number(end)-1);
end
```

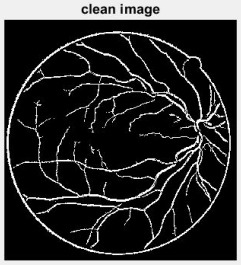


Test image 2

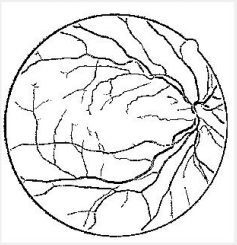
Filtered Image



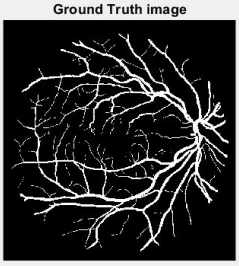
clean image



Complemented image

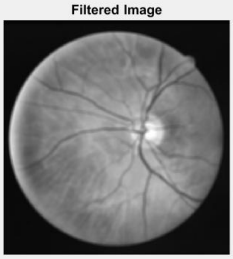


Ground Truth image

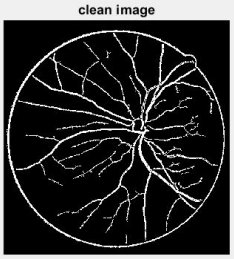


Test image 3

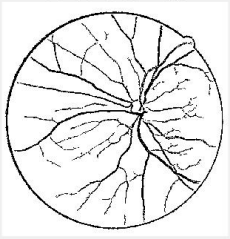
Filtered Image



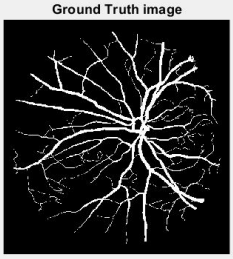
clean image



Complemented image



Ground Truth image



RESULTS AND SCORES

Images	Dice coefficient	Jaccard index
Test Image 1	0.6555	0.4876
Test Image 2	0.6392	0.4698
Test Image 3	0.6191	0.4484

CONCLUSION

Retinal vessel segmentation is performed on fundus images by setting appropriate parameters and sequences of filtering and morphological process using MATLAB code. It is observed that these vessels can be accurately segmented from fundus images and is validated by measures such as Dice and Jaccard scores by comparing it with the ground truth mask.