Knee Health Monitoring Through Emg using Ni-Data Acquisition

Sharon I,Aadhav I,Prathick Singh D,Muradi Lavanya Satyanarayan ,Anitha G,

Abstract- Knee joint is prominent joint, giving support to the entire body. Problems related to the knee joint such as fracture, genetic disorders, Ligament tear, and diseases like osteoarthritis etc. leads to Knee joint health problems. The adopted methodologies are X-Ray, CT, and MRI etc .This all requires periodical checkup and evaluated only when the person is having problem with the Knee joint. Continuous monitoring knee health is important and helpful for the needy. This papers aims to develop knee health monitoring device with the help of EMG signal which is acquired through vastus medialis and gastrocnemius muscles. These two are important muscles which are giving support to the knee joint. The two major skeletal muscles are investigated on the basis of their muscle reflection by giving different dynamic motions. This study includes adults, age ranging from 18-30 and aged adult from 50-60 .The EMG signals are taken from both the legs by using Muscle V3 sensor.NI-DAQ are used to acquire the signals. The result shows that there is a significant variance in the amplitude of the EMG signals with respect to the increasing age, the strength of the muscle signals which is the base for stability of the knee joint movement have been focussed in the results.

Keywords: EMG signals, EMG muscle V3 sensor, Vastus medialis, Gastrocnemius, dynamic analysis of knee flexor and extensor muscles, NI-DAQ.

I. INTRODUCTION

The major reason people visit doctor is injuries or pain at the knee position of the leg. On an average more than 10 million patient make a visit to the doctors because of problems related to knee joint like sprains and ligament tear as per the united states.

The process of standard examination isn't helpful in obtaining a quantitative feedback. Other diagnostic imaging methods are quantitative but they are quite expensive and along with it they are time consuming procedures.. Beyond the clinic, such as in the home or with wearable technologies, there are no viable solutions available for providing in-depth, quantitative joint health assessment.

The maximum stress is given to the knee joint of the body because it bares the whole weight of the body. As a result, it is the most injured joint in the human body [1] but also accounts for many severe injuries in terms of military personnel, and other populations engaged in high-performance activities.

Revised Manuscript Received on October 30, 2019.

* Correspondence Author

Sharon I , Studen, B.Tech, Department Of Biomedical Engineering, SRM Institute Of Science Technology.

Aadhav I, Studen, B.Tech, Department Of Biomedical Engineering, SRM Institute Of Science Technology.

B**Prathick Singh D,** Studen, B.Tech, Department Of Biomedical Engineering, SRM Institute Of Science Technology.

Muradi Lavanya Satyanarayan, Studen, B.Tech, Department Of Biomedical Engineering, SRM Institute Of Science Technology.

Anitha G, Assistant Proessor ,Department of Biomedical engineering, SRM Institute of Science and Technology

The calf muscles whose one half is formed by the gstrocnemius along with soleus muscle of the lower extremity which plays a major role in dynamic motions. The vastus medialis muscle which is present above the patella and also known as knee cap are used as reference muscles [2]

The health of muscles is diagnosed and accessed using a parameter called EMG (electromyography) which are controlled by the motor neurons of the nerve cells. The contraction of the muscle signals is caused by the motor neurons. EMG signals obtained can be helpful in revealing nerve dysfunction also well as problem related to nerve to muscle signal transmission. Surface electrodes are used to translate these signals into graphs, sounds or numerical values that are then interpreted by a specialist [3].

Motor unit such as muscle fiber conduction velocity and location innervation zones cannot be measured using needle EMG therefore surface EMG is been used [4].

Qualitative analysis revealed that the muscle activity patterns during standard and declined squats were similar, and quantitative analysis did not reveal any differences in EMG activity.[5]

EMG uses electrode stickers applied to the skin (surface electrodes) to measure the speed and strength of signals traveling between two or more points.

II. EXPERIMENTAL METHODOLOGY

A.EXPERIMENTAL DOMAIN

Fig[a].EMG sensor at Vastus medialis and Gastrocnemius [7].

The method of the study includes the use of an EMG muscle V3 sensor to measure the muscle activity around the knee joints. Ni DAQ device is interfaced with the biomedical workbench software to acquire the resulting EMG signal. The analog signals are digitized using Ni DAQ i.e. it acts as an interface between a computer and signals from outside world. The Ag/AgCl electrodes are used, fig[c].

They are Gel electrodes which are disposable and easy to use. Three disposable Ag/AgCl electrodes are placed in the knee joints muscles namely vastus medialis, Gastrocnemius, and the other electrodes is kept as a reference [3]. The Ni DAC device and the electrodes are connected via extension wires to the EMG sensor

After all the connections are done the procedure is started. The subject is asked to stand and sit for three times for 30 seconds. Similarly, signals are captured during joint flexion and extension. The signals are captured for both the legs using Biomedical workbench software.

B. EXPERIMENTAL APPARATUS

The measurement of the EMG signal from the muscles shown in fig[a] will be using an EMG sensor

(The Advancer Technologies EMG Muscle Sensor V3.0), cable and electrodes interfaced with NI-DAQ to acquire the signals, which further filters the acquired muscle signals and then rectifies it to around 20-30 mV which varies on the basis of muscle activity. Power supply voltage: min ±5V.The overall gain of the sensor is 15. This Muscle Sensor v3 is from Advancer Technologies produces an analog output signal. The signals are captured by the NI-DAQ system and the output is viewed in the biomedical workbench software. The signals can be viewed on the computer. The data acquisition is the process of measuring an electrical or physical phenomenon such as temperature, sound with a computer. This system is customizable, easy to use software, has high-quality hardware and good support. Specifications of NI-DAQ are analog input (2 channels, 200 kS/s, 16-bit) analog input and output; 8 digital I/O; power supply (+5V,±15V); compatible with biomedical workbench software.

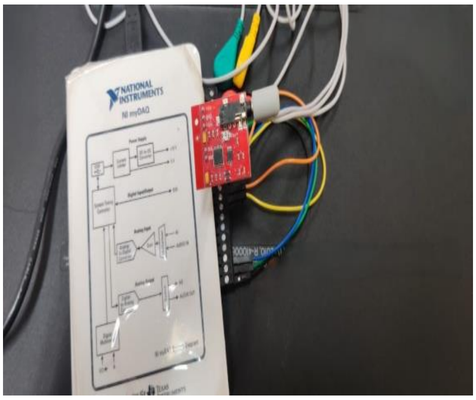


Fig [b].EMG Muscle V3 sensor with NI-DAQ

Fig [c] Disposable Ag/AgCl Gel electrodes

C. EXPERIMENTAL PROCEDURE

The experimental procedure involves the use of EMG muscle V3 sensor that is interfaced with the NI-DAQ system. Three disposable Ag/AgCl electrodes for each leg is placed on the above-mentioned muscles fig[a] for acquiring the signals. The direction of placement is very important for getting appropriate signals. The muscle fibers are the appropriate place to place the surface electrodes and for obtaining maximum muscle signals. EMG v sensors are connected to the two lower extremity muscles (vastus medialis and gastrocnemius) and EMG signals are obtained from both the positions of the leg. The electrodes are placed in such way that the noise from other muscles are avoided i.e. at the center of the muscle. Muscle signals are obtained for both the legs using the EMG sensors for four dynamic motions such as sitting, standing flexion and extension of the knee joint [6]. The signals are taken for 30 seconds. The acquired signals are obtained in the digital oscilloscope in the biomedical workbench for further analysis

D. ABBREVIATIONS

EMG: Electromyography
NI-DAQ: National Instruments Data Acquisition
Ag/AgCl:Silver/Silver chloride
kS/s: kilo sample per second.

III.EXPERIMENTAL RESULTS AND DISCUSSION.

The EMG signals were taken for the young and aged population. the muscle strength of upper portion of the knee and lower portion of the knee was analyzed on the basis of the amplitude voltage of the EMG signals. In the young populations, the amplitude was high and the muscle strength was good. Whereas, in the aged population we observed less muscle strength and lower amplitude of the EMG signals. The flexion and extension motions were also less compared with the young population.

The maximum amplitudes for vastus medialis of both the legs during sitting, standing, flexion, and extension have been shown in graphical representation for 30 seconds. Similarly, amplitudes for gastrocnemius muscle for all the four dynamic motions have been taken and analyzed.

Table[1]represents the left and right vastus medialis and gastrocnemius muscle EMG values of aged subject 1

Subject Age-59							
Left				Right			
Vastus Medialis		Gastrocnemius		Vastus Medialis		Gastrocnemius	
Lifting leg	Sitting and standing	Lifting leg	Sitting and standing	Lifting leg	Sitting and standing	Lifting leg	Sitting and standing
1.152671695	1.166361	1.157234669	1.160168	1.158538342	1.197649	1.207427263	1.147457
1.15169394	1.165709	1.156908751	1.158212	1.158212423	1.196672	1.200908661	1.147457
1.151368022	1.165709	1.153975368	1.157235	1.157560587	1.196346	1.195367932	1.146805

Table[2]represents the left and right vastus medialis and gastrocnemius muscle EMG values of aged subject 2

Subject Age-68							
Left				Right			
Vastus Medialis		Gastrocnemius		Vastus Medialis		Gastrocnemius	
Lifting leg	Sitting and standing	Lifting leg	Sitting and standing	Lifting leg	Sitting and standing	Lifting leg	Sitting and standing
0.891279221	0.894864	0.988731027	0.96005	0.705501556	0.692139	0.747871876	0.593709
0.890627384	0.893561	0.964612544	0.959398	0.70484972	0.691487	0.747871876	0.593709
0.889323652	0.892583	0.961027324	0.959398	0.704523742	0.690183	0.744286716	0.592405

Table[3]represents the left and right vastus medialis and gastrocnemius muscle EMG values of aged subject 3

Subject Age- 71							
Left				Right			
Vastus Medialis		Gastrocnemius		Vastus Medialis		Gastrocnemius	
Lifting leg	Sitting and standing	Lifting leg	Sitting and standing	Lifting leg	Sitting and standing	Lifting leg	Sitting and standing
0.894864	0.753739	0.988405	0.992968	0.88997	0.910509	0.984168	0.999914
0.893561	0.753739	0.987753	0.992642	0.88965	0.910183	0.983842	0.997125
0.892583	0.753413	0.987753	0.992316	0.88965	0.909857	0.983842	0.995575

Table[4]represents the left and right vastus medialis and gastrocnemius muscle EMG values of normal subject 1

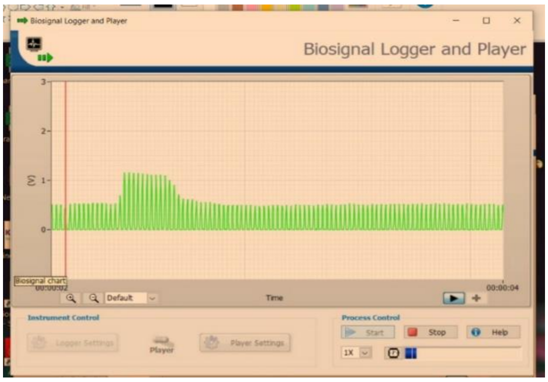
Subject Age-20							
Left				Right			
Vastus Medialis		Gastrocnemius		Vastus Medialis		Gastrocnemius	
Lifting leg	Sitting and standing	Lifting leg	Sitting and standing	Lifting leg	Sitting and standing	Lifting leg	Sitting and standing
3.648285	3.115397	2.579249	2.306123	2.232464	2.172819	3.24153	2.874863
2.772197	3.04793	2.395101	2.274834	2.227901	2.122627	3.241204	2.668226
2.546982	3.032286	2.368375	2.268967	1.999101	1.969442	3.231752	2.608582

Table[5]represents the left and right vastus medialis and gastrocnemius muscle EMG values of normal subject 2

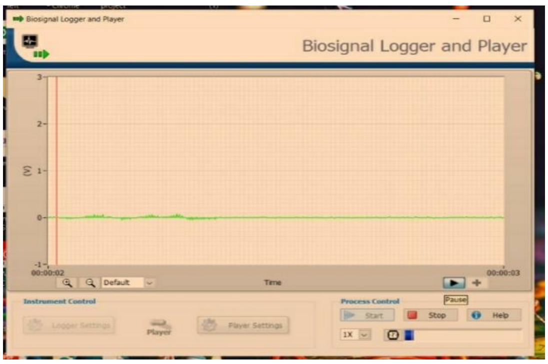
Subject Age-21							
Left				Right			
Vastus Medialis		Gastrocnemius		Vastus Medialis		Gastrocnemius	
Lifting leg	Sitting and standing	Lifting leg	Sitting and standing	Lifting leg	Sitting and standing	Lifting leg	Sitting and standing
2.208019	2.670508	2.328879	2.14328	2.128879	2.001433	2.06559	2.437284
2.06559	2.664641	2.208796	2.092143	2.087961	1.921426	2.019257	2.31005
2.047368	2.659752	2.13682	2.08723	2.03682	1.872302	1.947368	2.276737

Table[6]represents the left and right vastus medialis and gastrocnemius muscle EMG values of normal subject 3

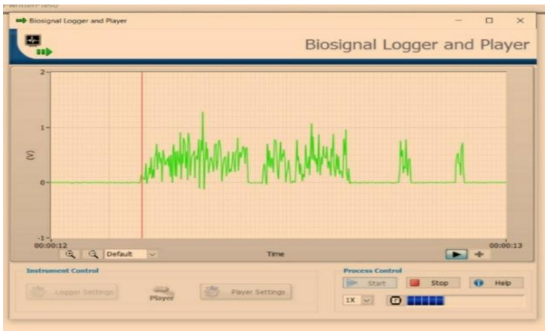
Subject Age-23							
Left				Right			
Vastus Medialis		Gastrocnemius		Vastus Medialis		Gastrocnemius	
Lifting leg	Sitting and standing	Lifting leg	Sitting and standing	Lifting leg	Sitting and standing	Lifting leg	Sitting and standing
3.155159	2.428671	2.524819	2.844552	2.587071	2.844552	3.340286	3.457945
2.852375	2.332849	2.395427	2.769264	2.528078	2.769264	2.830538	3.147663
2.513086	2.290804	2.378153	2.766982	2.524819	2.766982	2.675071	2.868345



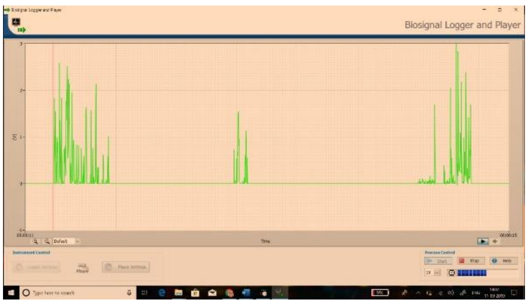
Fig[1] represents EMG signals of vastus medialis and gastrocnemius muscle of aged subject 1



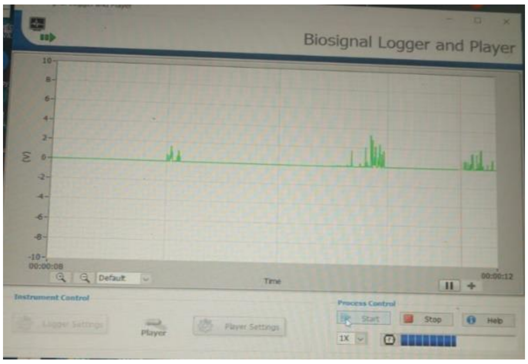
Fig[2] represents EMG signals of vastus medialis and gastrocnemius muscle of aged subject 2



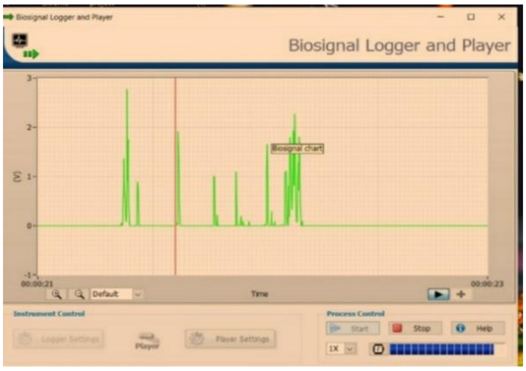
Fig[3] represents EMG signals of vastus medialis and gastrocnemius muscle of aged subject 3



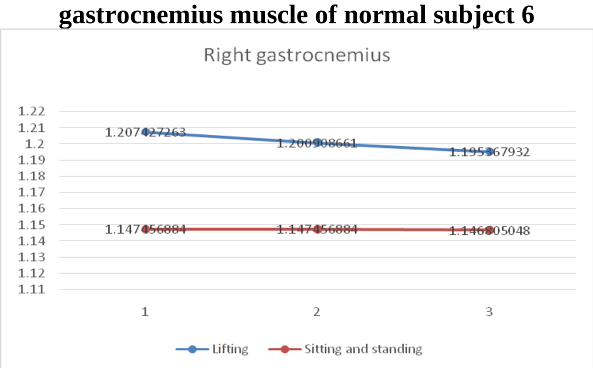
Fig[4] represents EMG signals of vastus medialis and gastrocnemius muscle of normal subject 4



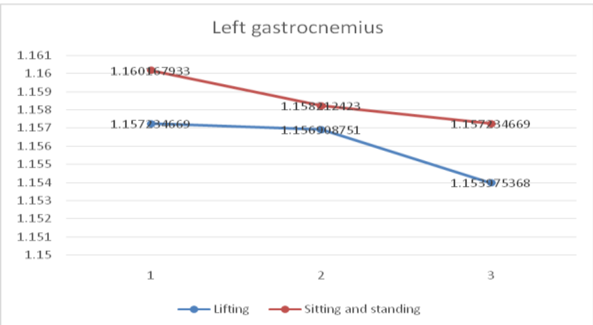
Fig[5] represents EMG signals of vastus medialis and gastrocnemius muscle of normal subject 5



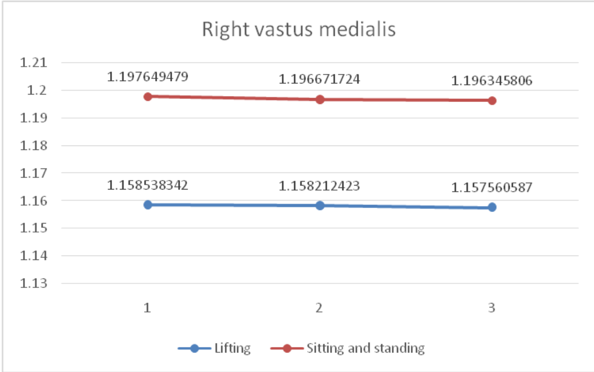
Fig[6] represents EMG signals of vastus medialis and gastrocnemius muscle of normal subject 6



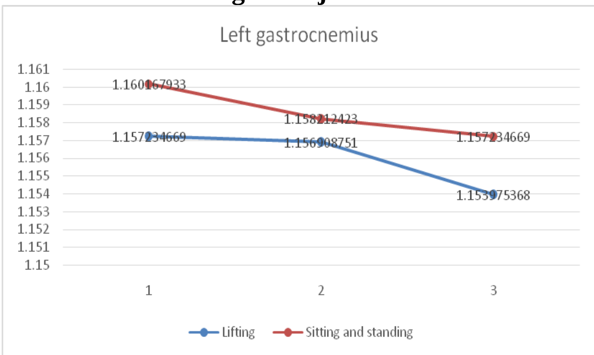
Fig[1.a] dynamic movements of right gastrocnemius of aged subject 1



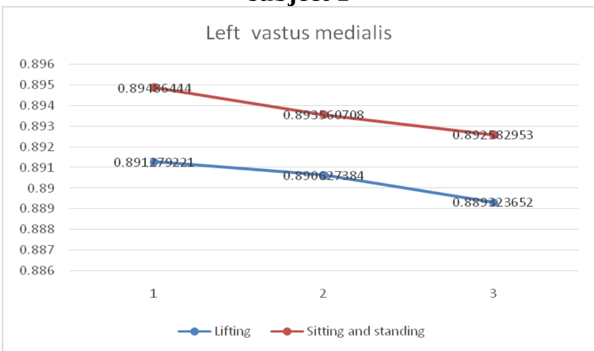
Fig[1.b]dynamic movements of left vastus medialis of aged subject 1



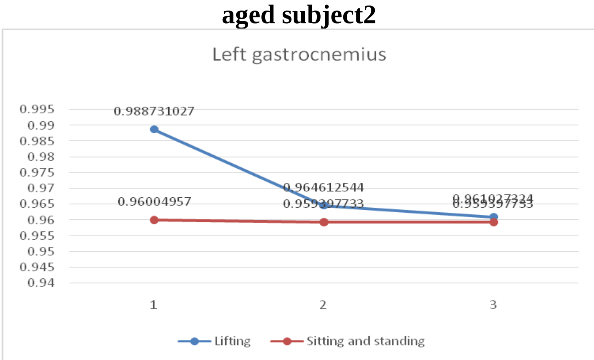
Fig[1.c] dynamic movements of right vastus medialis of aged subject 1



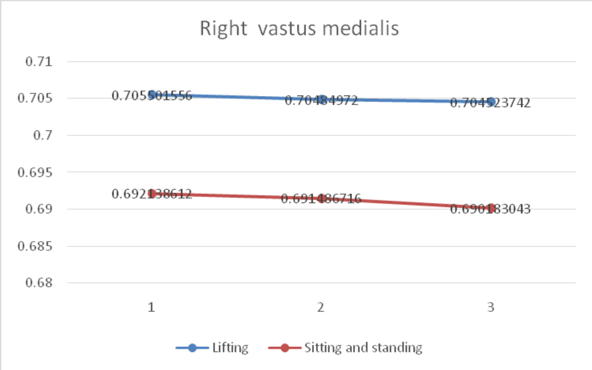
Fig[1.d]dynamic movements of left gastrocnemius of aged subject 1



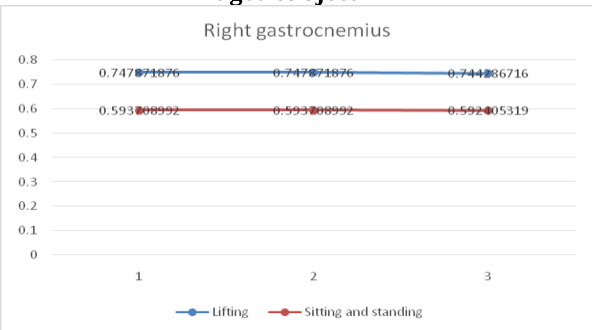
Fig[2.a]dynamic movements of left vastus medialis of aged subject2



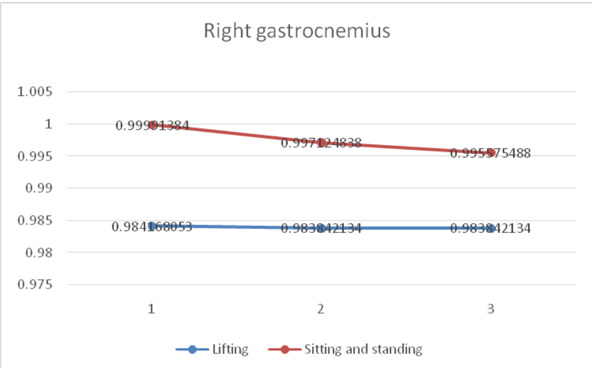
Fig[2.b]dynamic movements of left gastrocnemius of aged subject 2



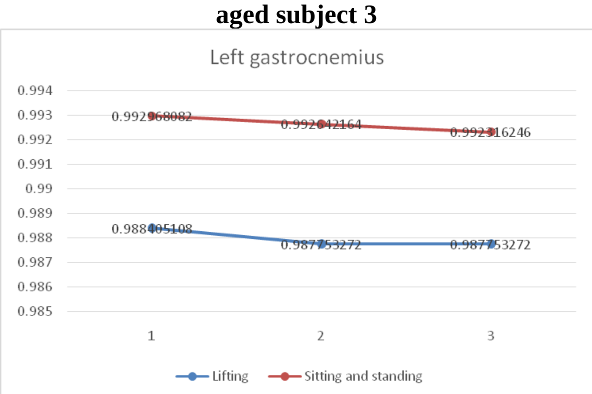
Fig[2.c]dynamic movements of right vastus medialis of aged subject 2



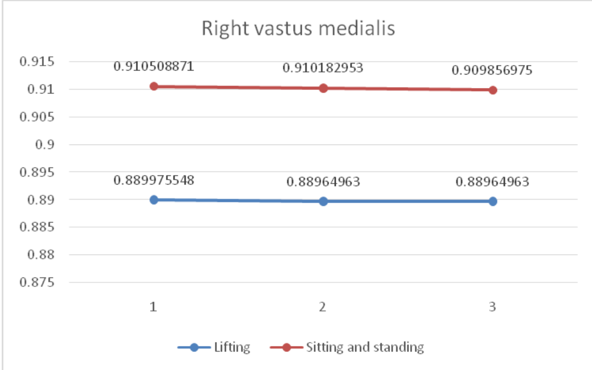
Fig[2.d]dynamic movements of right gastrocnemius of aged subject 2



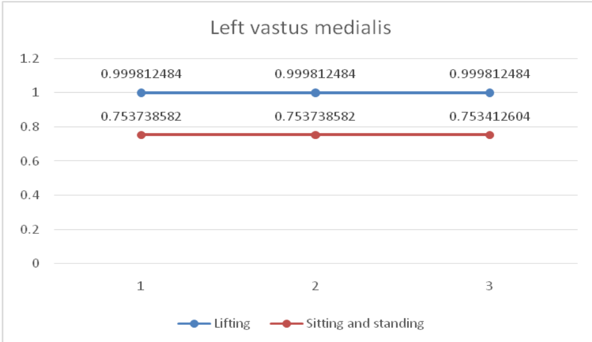
Fig[3.a]dynamic movements of left vastus medialis of aged subject 3



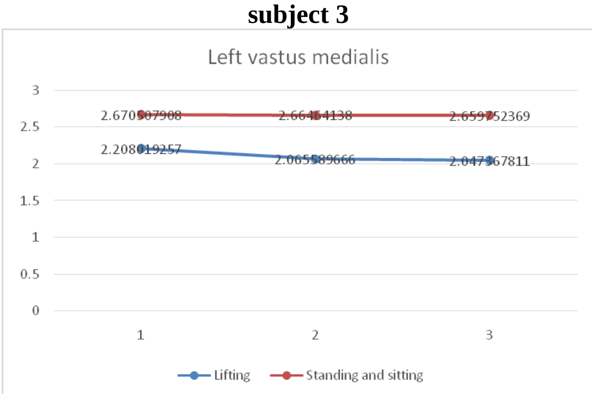
Fig[3.b]dynamic movements of right gastrocnemius of aged subject 3



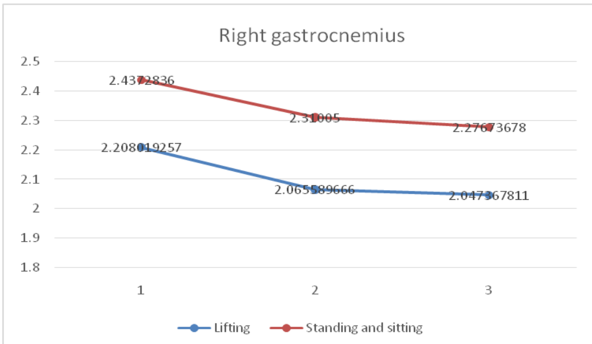
Fig[3.c]dynamic movements of right vastus medialis of aged subject 3



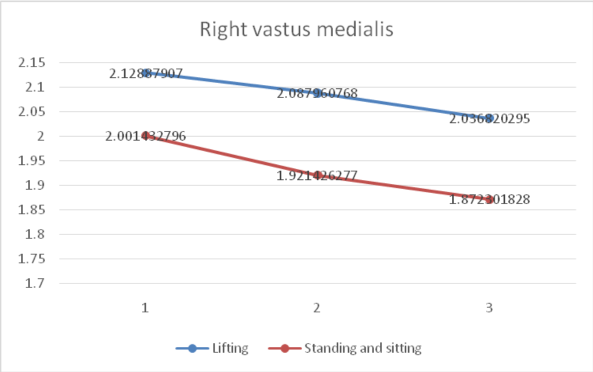
Fig[3.d]dynamic movements of left gastrocnemius of aged subject 3



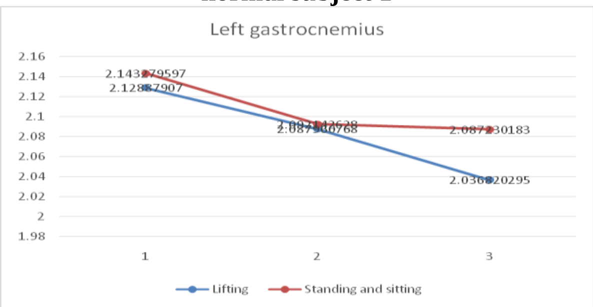
Fig[4.a]dynamic movements of left vastus medialis of normal subject 1



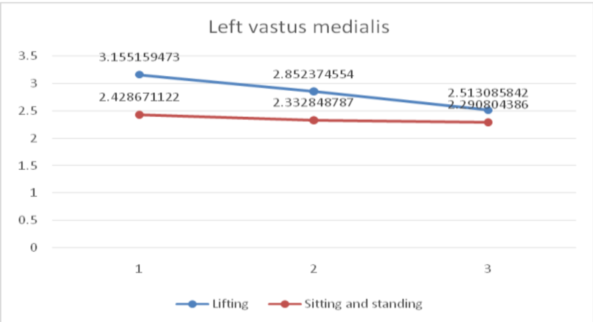
Fig[4.b]dynamic movements of right gastrocnemius of normal subject 1



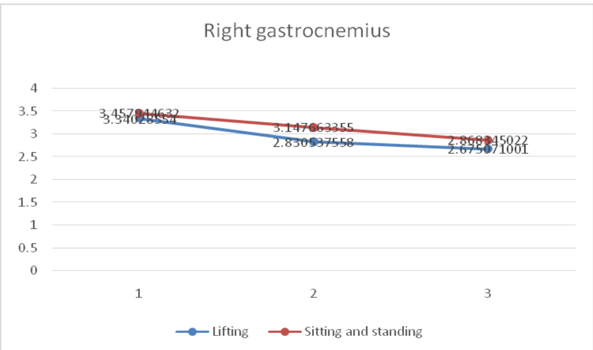
Fig[4.c]dynamic movements of right vastus medialis of normal subject 1



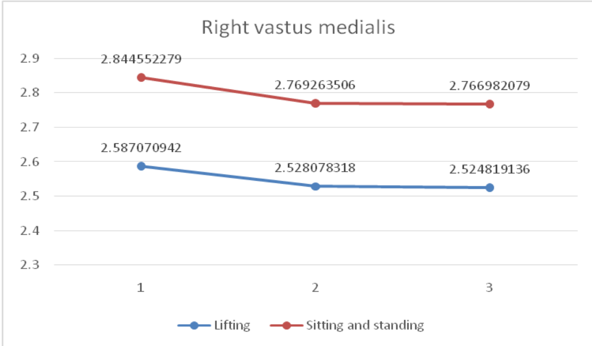
Fig[4.d]dynamic movements of left gastrocnemius of normal subject 1



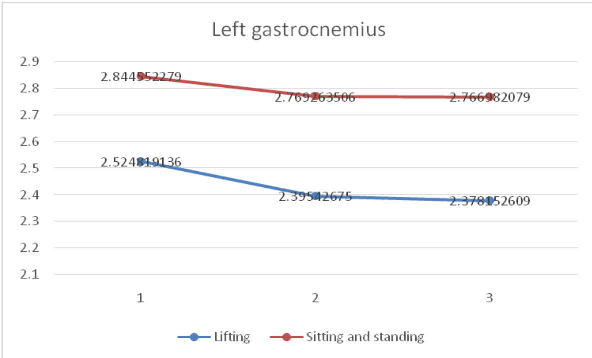
Fig[5.a]dynamic movements of left vastus medialis of normal subject 2



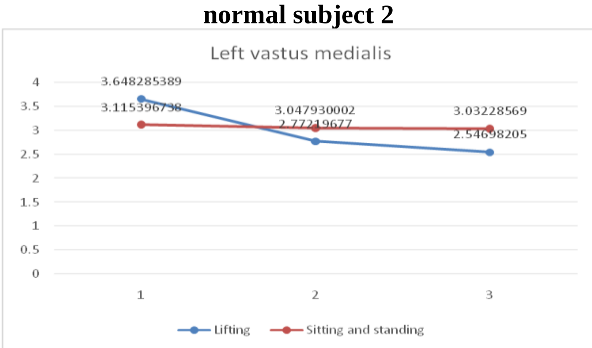
Fig[5.b]dynamic movements of right gastrocnemius of normal subject 2



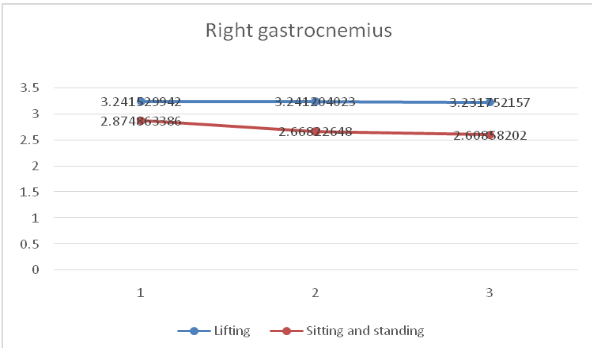
Fig[5.c]dynamic movements of right vastus medialis of normal subject 2



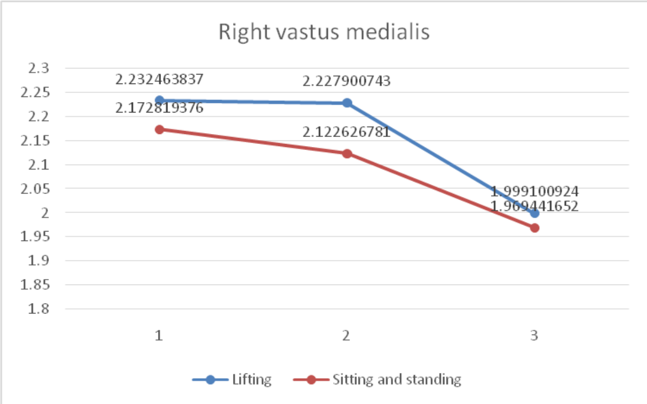
Fig[5.d]dynamic movements of left gastrocnemius of normal subject 2



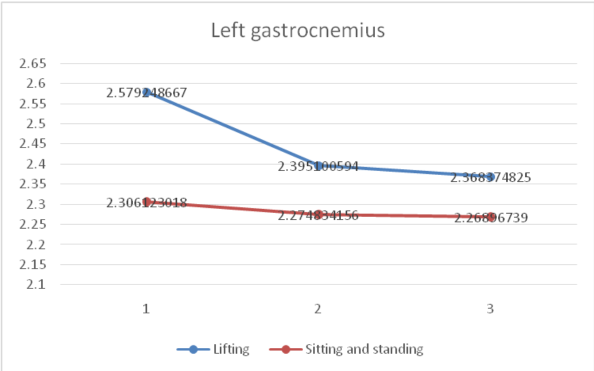
Fig[6.a]dynamic movements of left vastus medialis of normal subject 3



Fig[6.b]dynamic movements of right gastrocnemius of normal subject 3



Fig[6.c]dynamic movements of right vastus medialis of normal subject 3



Fig[6.d]dynamic movements of left gastrocnemius of normal subject 3

Tables[1,2,3,4,5,6] represents the EMG values of the Vastus medialis and Gastrocnemius muscles of all the four dynamic motions(sitting, standing, flexion and extension)of aged and normal subjects respectively. From the tabulation after amplification, it showed that the values ranged from 0.59V to 1.12V for the aged population and 1.87V to 3.64V for the normal population. Fig[1,2,3,4,5,6] shows the EMG signals picked up from both the population and it showed significant differences. The graphical representation of the dynamic movements of both the muscles for both the population is shown above. After the analysis, it can be seen that the muscle activity around the knee joints weakens as the age increases.

IV.CONCLUSION AND FUTURE WORKS

The stability of the knee has been analyzed on the basis of vastus Medialis and gastrocnemius muscles by using the EMG signals acquired from the Ni-DAQ system. There is a decrease in the muscle activity with respect to aging which shows as age increases the muscle strength decreases which affects the muscle activity of the lower extremity of the leg. Thus, with aging of the muscles around the knee weaken and thus deteriorates the knee joint motions. In this paper, we have analyzed EMG signals of the dynamic movements (sitting, standing, flexion and extension) of the Vastus medialis and Gastrocnemius muscles for aged and normal populations. In the future, we would measure and analyze the impedance and acoustic signals of the knee joint which would help in better analysis of the knee health.

REFERENCE

1. J. H. Lubowitz, B. J. Bernardini and J. B. Reid, Current concepts review:comprehensive physical examination for instability of the knee, Am. J. Sports Med., Vol. 36, No. 3, pp. 577-594, March2008.
2. Md. T. I. Khan ; K. Teramoto ; Koga Shunji ; Kurita Tomoaki, "EMG signals in muscular co-activations for dynamic analysis of knee joint" IEEE - International Conference -2014
3. F. Robert et al., The anatomy of the medial part of the knee. J. Bone Joint Surg Am., Vol. 89, No.9, pp. 2000-2010, September2007.
4. R. Merletti, A. Holobar and D. Farina, Analysis of motor units with high-density surface electromyography, J. Electromyography and Kinesiology, Vol. 18, pp. 879-890,2008.
5. FSM Alves, FS Oliveira, CHBF Junqueira, BMS Azevedo and VC Dionisio, Analysis of electromyographic patterns during standard and declined squats, Rev Bras Fisioter, Vol. 13, No. 2, pp. 164-172, April 2009.
6. Y. I. Al-Mashhadany, Measurement of human leg joint angle through motion based on electromyography (EMG) signal, IJCCCE, Vol. 11,No. 2, pp. 46-55, January2011

AUTHOR PROFILR

Sharon I B.Tech final year student in department of Biomedical engineering, SRM Institute of Science technology.

Aadhav I B.Tech final year student in department of Biomedical engineering, SRM Institute of science and technology.

Prathick Singh D , B.Tech final year student in department of Biomedical engineering, SRM Institute of science and technology.

Muradi Lavanya Satyanarayan B.Tech final year student in department of Biomedical engineering, SRM Institute of Science and technology.

Anitha G, Assistant Proessor in Department of Biomedical engineering, SRM Institute of Science and Technology