CHAPTER 1

INTRODUCTION

CHAPTER 1 - INTRODUCTION

1.1 Project Background:

In the past 50 years there are ~~several~~ research related to the gait analysis ~~is going on~~. According to the report of the year 2018 of World Health Organization, it is declared that more than 15% of world's population [1]~~from disability.~~ Moreover, approximately the adults between 110 million till 190 million [1] are suffering from the complications and problems of lower limb disabilities of gait pattern. More than a billion people are suffering from some sort of problems related to the disabilities, this corresponds is about 15% of the total world population [1].

As stated by the ICF (International Classification of Functioning, Disability and Health) disability is define as the activity limitation within the gait pattern. Problem related to the gait are increasing due to the major factor of chronic health problems, some major issues are Parkinson disease [2], hemiplegia, paraplegia, stroke and several others. Patients related to this disease need additional care and concern as they are not able to perform their gait properly. Gait problems are also increasing in adults due to the issues related to the stress and depression, in which most common are negative attitude, limited social interaction and anxiety. In the past years different types of chronic comparative analysis have been done by the researchers, one of the gait comparisons is between the young [3] and elder subjects. Several researches work on the alignment of the foot angle [2] ~~(as this is the most critical analysis data of the gait pattern which is done in 1996),~~ more over the major step which has been taken by the L.Klenerman, R. J. Doses, C. Weller, A. Leeman and P. Nicholson is that they work for bringing out gait analysis from laboratory into the clinic [4], also the neurology researches have played important role in solving the chronic disorders problems which are linked with the gait patterns.

Due to the past research work of the several researchers now it has become very helpful for the new researches to work on the gait pattern. From 2010 the wearable sensors [5] as well as particular objective methods have been used for

the analysis of the pattern. All these work are very effective in their own way but the main problem is that, they are not portable[6] and every one of them is fully linked with the wearable sensors. So in this new method of gait pattern analysis of the chronic disease we use the portable device [6] which is the good achievement towards the problem solving situation of the disease.

1.2 Introduction to the Project:

Gait has been the first discovery when the problems of disability were taken as a serious issue of mankind care [7]. The disability has variation of problems but the most major problems are related to the chronic diseases. Since 1970s, the disability responses [5] have changed emerged on vast amount due to self-organization of disabled people [6, 7]. While ~~in~~ the beginning of the gait problems the institutes provide complete guidance for taking care of the patients but luckily now school, colleges and universities are also providing knowledge about the gait disorders.

Before moving towards the Gait disability, firstly we should know what is disability? ~~So basically d~~isability is ~~the~~ complex and multidimensional disorder. This is usually occurring due to the heavy load bearing, accidents, stress, chronic disease and mostly neurological [1] problems. Two major physical barriers are usually faced by the patients ~~that~~ are Social issues [8]and Physical issues. ~~Socially they are considered as the unhandy and clumsy, while physically they are so disturb and discomfit.~~ The medical model of the gait disability is very much similar to the disability of lower limbs; it includes the dis-functioning of the limbs, bending of the spinal cord, amputee limb problem and several chronic diseases. Gait disability is the most dynamic interaction between the lower limb disorders with the health conditions both the personal and environmental conditions will affect the gait pattern of the patients. In year 2005 research has been conducted on the alignment and foot angle stance phase [3] of the gait analysis. In this analysis they quantify the relationship between the lower extremity, foot progression, adduction of the limb and abduction of the limbs with

several [2] other factors included. There results suggest that the alignment of the foot [2] will help in predictions of the future problems.

After wards the analysis data work will continue towards the inactivity of the limbs, gait speed [8], gait balance in the years of 2010 till onwards[2]. Main purpose of all the experiments are that is to identify the abnormal gait pattern and then try to overcome these entire problems[9] with specific and effective solutions. Mostly they all focus on the chronic disorders as they are more dangerous towards the human body gait pattern. Also the Stephanine Studenski and his partners have done the survival and gait speed analysis among the adults in the year of 2011 [10], they conduct this individual data collection among 34,485 adults of age 65 and above. Furthermore, this type of initial research has been done in the year of 2010 by the Thomas Jefferson University [9], and the only difference is that they work on the balancing disorders of the adults.

While the automatic monitoring regarding the gait parameters are now done by the wearable sensors as to evaluate the results and condition of the subjects. The algorithm which is used will be work on the spatiotemporal [10] gait parameters, usually used for the targeted population of the particular country. Main objective of all those analyses are stride length, strep length, cadence, toe angle etc. But recently in the year of 2015 and 2017 automatic i-walkers are designed by the Joaquin Ballesteros and his team, as their approach is novel towards the analysis of the gait pattern of lower limb disables. This system integrates the sensors to measure the force applied, and then the data is transfer into the Pasco Capstone software for measuring their forces in the graphs, graphs which are used to identify the condition such as scatter graphs. The results which are obtain, basically the comparison between the healthy and the disable individuals.

This rehabilitation based research has already been done in past years of 2015 and 2016. In this research, the modified analysis of gait pattern along with the comparison of normal and chronic disease have been performed over the patients, by which the researchers predict the future results of the analysis that out of right and left; on which of the side the gait pattern is getting imbalanced or disturbed and whether there are the chances of them to be corrected or not. Gait analysis of

such kind of lower limb disabilities is going to be conducted for the first time for data gathering to make the researchers to realize to get assistance for the future predictions and to create new devices [11] for gait analysis and to get new approaches through the mobility analysis of lower limb disabilities using the static walker.

1.3 Problem Statement:

Following are the problem statements which need to be address for the completion of this project. The objectives which need to be fulfilled by the end of the process of creation of

- Different walkers have come up come for solution but are unable to deliver comfort support to the mobility challenge. But with walker this can give support up to 64% of the vertical load [12]. Design of walking frame has not been effective enough due to the lacking in selection of walker having the factors which can lead towards the unbalancing of disabled people because the walker is basically designed for the amputee which requires adjustability with advanced safety measures.
- The panel of large amount of specialists was used to sit with a huge setup of system to perform gait analysis of the patients and the data was accessed by confining the patient in a room by help of peripherals which were given to the patients to wear.
- Doctors and Physical Therapist don't have related data of neuronal responses regarding patient's important needs.
- Not capable of measuring force which is applied by the patient.
- Not able to detect the fully applied force and motion.

1.4 Project Objectives:

The objectives which need to be fulfilled by the end of the process of creation of this rehabilitation related project are stated below:

a) ~~The individual enhanced software with modification is designed which is performed with a few specialized doctors and engineers for the provision of~~ better gait monitoring with the statistical data storage interfacing with the new recorded measurements of gait patterns of the patient [12].

b) To develop a software programming to create a compatibility of walker with the upcoming rehabilitation devices in such parameters of researches.

c) To carry comfort in handling the frame due to the adjustable design of the walking frame apart from the age or size of the person, this provides a user friendly environment.

d) To replace heavy equipment with the simple comfortable and secure walker.

e) Conducting walk tests ~~for~~ different periods of time of patients of various age limits to meet the standards according to their age group.

f) Analysis of fully applied force is measured on both the sides with the help Pasco capstone load cell sensors.

1.5 Scope of Research:

The scope of the project has ~~many~~ limitations according to which the parameters are stated:

a) To make the people of society to be able to fulfill own necessities with Self-sufficiency.

b) It is crucial for the rehabilitation field as the gait with proper design is not available for the disabled and amputee people needs.

c) Gait analysis is used to assess and treat individuals with conditions affecting their ability to walk.

d) Standards of measurements of the required data regarding the gait pattern will be limited to the readings of the 40 patients.

e) Graphical representations of standard versus applied forces can provide information about the patient's genomic aged and osteoporotic patients.

f) It is essential in orthopedic lower limb patients to monitor partial falls.

1.6 Significance of Project:

Project has number of applications which gives prove to its significance some of them are listed.

a) Gait analysis is crucial for the rehabilitation field ~~with proper design for the disable and amputee people with right walking style~~.

b) In older version walker patient used treadmills and many other wearable sensor [11] and goes to many center, but in our ~~walker~~ the patient will be used easily at everywhere and every time.

c) The restriction and evaluation is given for those patients who will be bear some weight for walk with walker and also for those amputee patients who unable to walk.

d) A new methodology that evaluates scale scores automatically for the disable or amputee person using spatiotemporal gait parameter [13].

1.7 Major Contributions:

There are some of the major contributions which should be kept under consideration to represent the project to be able for a few contributed purposes:

a) The walker will be portable and system can be executed on any unspecified place and time, whenever there would be the necessity [12, 13].

b) As compare to the previous systems, this system is not complex and easy to operate.

c) The designed system has the method which is used in [12] to systemize the force, spatial, temporal, and temporal parameters with respect to the weight of user and length of user's leg [12, 13].

d) The walker is user friendly and not difficult to operate.

CHAPTER 2

LITERATURE REVIEW

CHAPTER 2 - LITERATURE REVIEW

2.1 Introduction

About past 20 years there is revolutionary change in the field of rehabilitation for the patients of different disabilities. As the time passes on the modification are increasing day by day. In the initial when the work started the scientist and engineers work on the walkers after that they modify according to the needs of the patients. When the changes have been started from the initial stage they get to know that every patient has some other type of problem is their disability. The trend of using walkers has been start from the 20th century and in the past 19th century the crutches and canes were used for support in walking.

2.1.1 Techniques:

The techniques which were discussed in the past research papers are listed as follows:

- Reliability of walking speed (Year 1996)
- Gait analysis during treadmill and over ground locomotion in children and adults (Year 1997)
- Quantitative Human Gait analysis (Year 2000)
- Gait analysis in patient operated on for sacrococcyogel teratoma (Year 2004)
- Gait analysis of Patients following total knee replacements (Year 2007)
- Observational gait analysis in traumatic brain injury (Year 2009)
- Gait Analysis in Lower-Limb Amputation and Prosthetic Rehabilitation (Year 2014)
- Limb Dominance, Foot Orientation and Functional Asymmetry during walking gait (Year 2017).

2.2 Reliability of Walking Frame:

In the year of 1996, the University of Teesside U.K. works on the reliability pattern of the walking. The main focus of the research is to focus on the spatial gait parameters of the walking pattern. Furthermore, they worked on the walking speed of the elderly patient. The data has ~~been~~ collected between the patients [2] of 60 to 79 years. The speed analysis was done by the help of specially designed sensors but overall some flaws have been identified in their research work:

- They focus only the walking speed
- The condition they generalize is to walk 200m for 15min which difficult for elderly patients
- The sensor works on temperature, so the result will vary when temperature change.

2.3 Gait analysis during treadmill and over ground locomotion in children and adults (Year 1997):

The research has been done by H.Stolze and his team. The research used treadmills in the analysis of the gait pattern within the children [3] and adults. They perform the comparative analysis between normal gait walk and treadmill walking pattern. One of the achievements is that they noted swing phase has been increase by 5% in adults. The flaws found in it are as follows:

- The work is only normal and healthy patients
- No equal distribution of forces has been calculated
- Amputee patient's readings has not been taken

2.4 Quantitative Human Gait Analysis (Year 2000):

This paper discussed the gait recognition and estimation during the locomotion. The kinematics basics have been applied for gait recognition; they

used 20 [4] students for analysis of the data. The methods used are Gaussian and bootstrap for the recognition and estimation.

There was a flaw which was present in it; is that the force applied by the samples was not measured in this research as there is no force factor involved. The discrete time measurements are calculated.

2.5 Gait Analysis in patient operated on for sacrococcyeal teratoma (Year 2004):

The research has been conducted on the sacrococcyeal teratoma patients. There gait analysis and pattern of body posture conductions will be monitor properly. Those patients who suffer from the surgery [5] there pelvic and perineal region conditions have been noted properly. The flaws present in it, are stated:

- The research is very concise and limited only one pattern
- Only 6 till 13years of patient's volunteer in research work
- They work only the tumor size and weight rather than the gait pattern of that patients

2.6 Gait analysis of Patients following total knee replacements (Year 2007):

The research conducted on the patients of the total knee replacement, they asked the volunteers to perform the gait and then monitor their pattern. They predict the less total knee motion during gait and with less knee flexion during swing than controls. Kinetic [6] discrepancies between patients and controls were also identified.

It contains the a flaw that the research lacks the main feature key[11] points of swing and stance phases such as effect and short distance of stride and step length.

2.7 Observational gait analysis in traumatic injury (Year 2009):

Research conducted on the 30 ambulant participants who are receiving physiotherapy for mobility[8] regulations. Kinematic and ground reactions data were gathered during the research. Observed inaccuracies were also calculated, the adult inaccuracy is low as compare to the younger patients [8]. Its flaws were determined:

- The data is in desecrate form not in the continuous form
- The results show only 30-50% of accuracy, so there is around 50-70% of error in the results

2.8 Gait analysis may help to distinguish hereditary spastic paraplegia from Cerebral palsy (Year 2011):

HSP (hereditary spastic paraplegia) is the genetic disorder of the brain, this disease cause spatiality in the lower limbs and the patients is not able to walk properly. The research is the comparison between the gait analysis of cerebral palsy and HSP [7] patients. Similarities between both the groups of patients has been identified and concluded that may be this will help in future surgeries. Its disadvantages were also notified below:

- There is no mathematical calculation of gait pattern, work is only limited that patient, whether has previous back ground of surgery or not and is he able to walk or not.
- The subjects of research are very less in number i.e. only 29 individuals have been taken.

2.9 Gait Analysis in Lower-Limb Amputation and Prosthetic Rehabilitation (Year 2014):

The patients who volunteer in this research work are those who suffer some sort of amputations in their body and due to that amputee they are not able to

perform proper gait. They evaluate the gait characteristics [11] and the diversion in the gait pattern of normal and disable patients. There were a few disadvantages which are as follows:

- Wearable sensors were used in the research
- Treadmill are used which is difficult to use by the disable patients
- limited work on stance and swing phase

2.10 Limb dominance, foot orientation and functional asymmetry during walking gait (Year 2017):

This research is about the hypothesis that asymmetries are present in the lower limbs and the ground reaction force has been applied on it, which cause different orientation or limb dominance [10] in the body. In the final result they have predicted that all the patients have the right limb dominance. The flaws are as follows:

- Only right leg dominance patients have been taken.
- No data of spatiotemporal gait parameters has been discussed.

2.11 Overall past Summary:

From 1995 till 2017 ~~[7,8][10]~~ all the work has been done in gait analysis, gait pattern recognition and walking aid gait devices are very concise and particular at the point. Some has work on the swing and stance phase and some papers have only work on the spatiotemporal gait parameters. In approx. every research paper the researchers used wearable sensors, which is not very convenient by the patients. ~~So~~ for overcome this problem, we have designed the model which will not use any wearable sensor and give accurate results regarding the force of the body. Furthermore, the spatiotemporal gait parameters are also being measured for the accuracy of results.

CHAPTER 3

METHODOLOGY

CHAPTER 3 - METHODOLOGY

3.1 Introduction:

The i-Walker platform is a special walker that has been developed for user support and monitoring [12]. Walker pre phase contains a load cell sensor, HX711 amplifier and Arduino interfaced with a laptop. The Phase I model A and B contain four load cell sensors placed on each leg of the walking frame. Both the handles of the walker contain the force sensors, which are used for measuring of the individual left and right force of the disabled patient in which the force on the one side of the handle bar will increase and the force of the other side will be decreased. Hence each and every variation in the gait pattern of the patient will be detected by the force sensors.

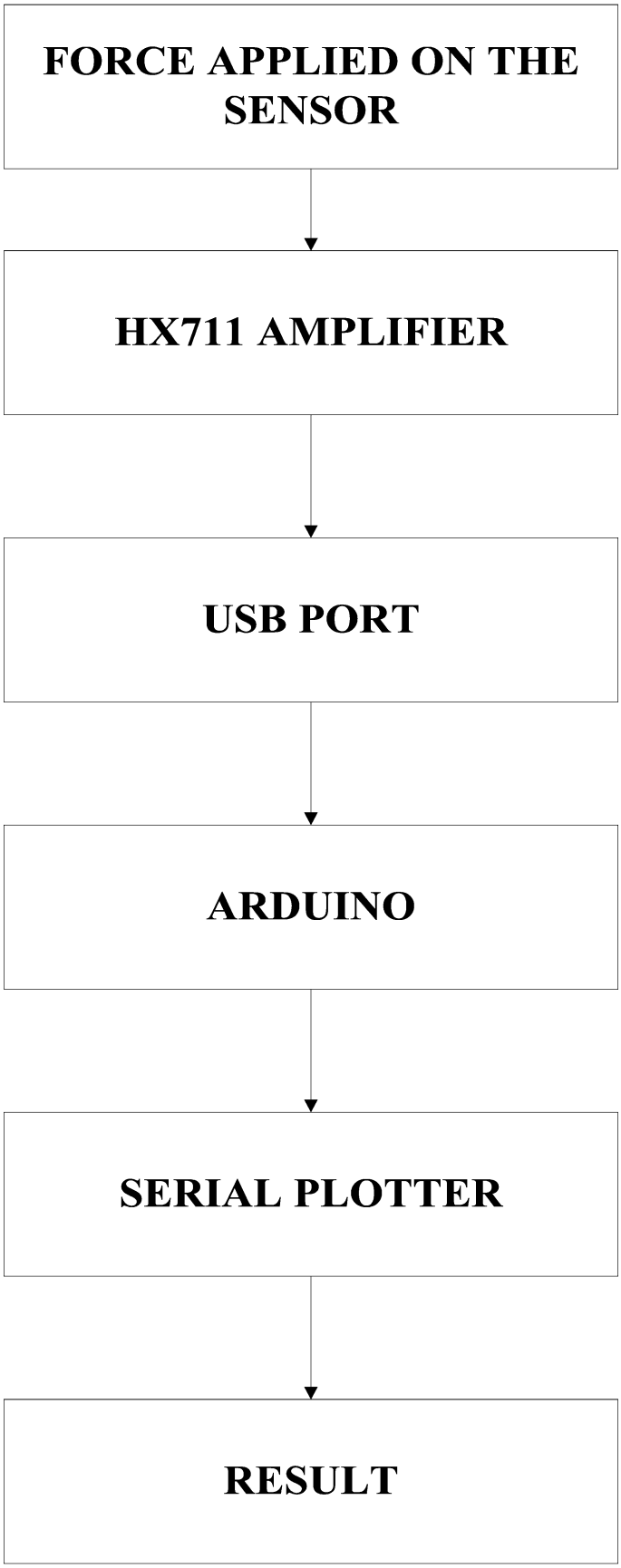

Figure 3.1.1: Pre-Phase Block Diagram

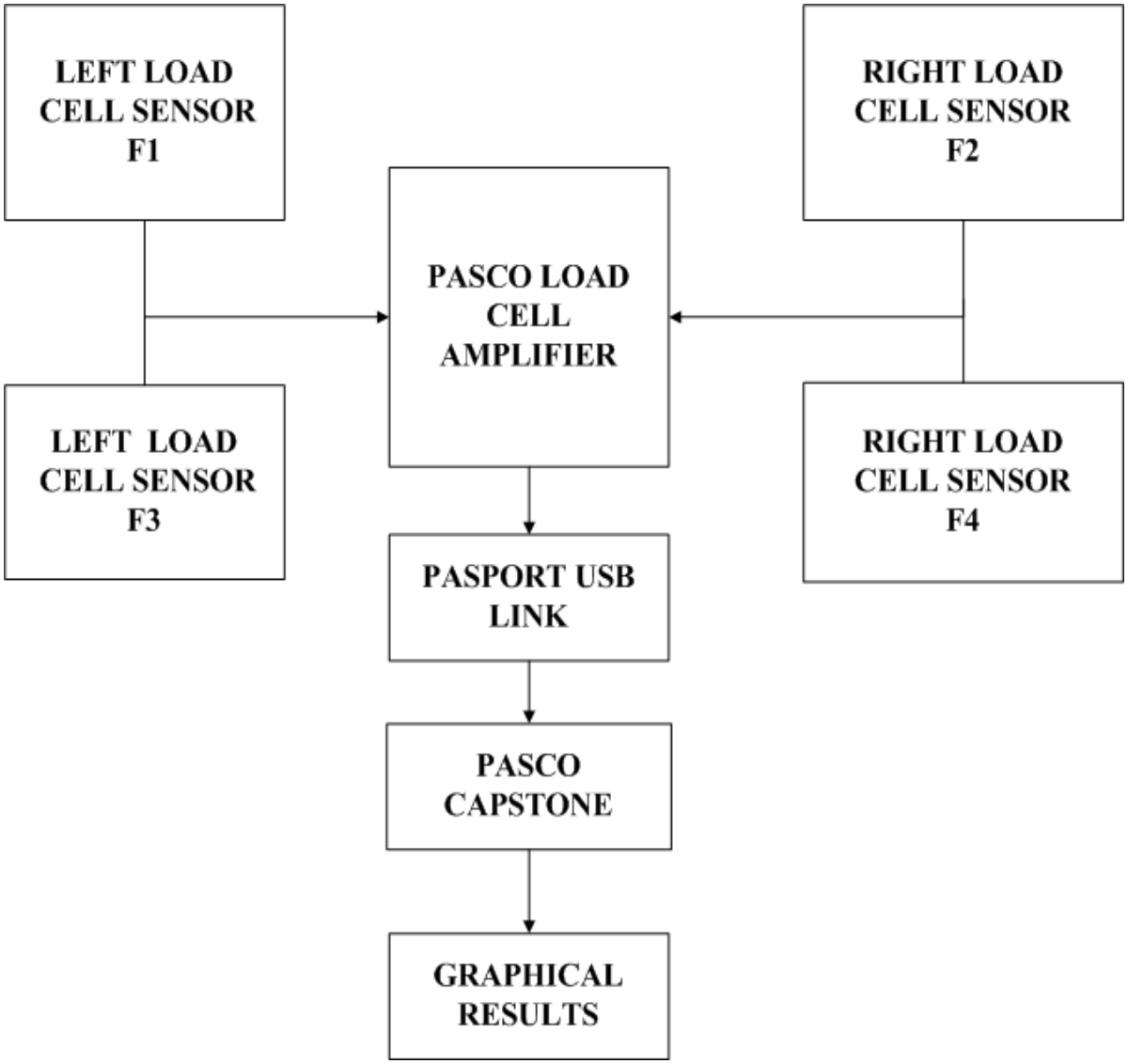

Figure 3.1.2: Block Diagram of model A and B

In the above block diagrams (figure 3.1.1) and (figure 3.1.2), we have discussed the main idea of our final year project. The project is divided into two main phase i.e Pre-phase and Phase model A and Phase Model B. The process begins with the data collection of disabled patients from their upper limbs, goes onto the Pasco Capstone force sensors after that it will be received by the Pasco Capstone software and then result will be in the form of digits and graphs.

3.2 Proposed Method:

We proposed a methodology to obtain spatiotemporal gait parameters by the help of walking aid force sensors and tested it on different volunteers. The volunteers are divided into two main groups i.e Genomic aged patients and Osteoporotic patients. No external wearable sensors are used for obtaining results in the process. The method which has been proposed in the above block diagram (figure 3.1) is depending on the non- wearable force sensors. These sensors are specially designed for collection of forces which are applied by the upper limbs [12]. When the patients start walking by grabbing the walker, contains the Pasco force sensors they start measuring the applied forces from the left side of the body and from the right side of the body. Using different type of spatiotemporal gait parameters, we are able to characterize the osteoporotic and genomic conditions.

Various types of forces sensors have been available in the market like Load cell, Load cell disk sensor, Straight bar load cell, Pasco capstone force sensors and several others are available. So in the Pre-Phase the Load Bar sensors are used and in Phase 1 model A and B Pasco capstone force sensors are used. The main sensor which are used in the Pre-phase model is the load cell sensor (figure 3.2(a)) connected to the amplifier HX711 (figure 3.2(b)). The amplifier is used for enhancing the force signals, collected by clinical disable patients. While in the Phase 1: Model A (figure 3.2(c)) and Model B (figure 3.2(d)) contain the Pasco capstone sensors.

Figure 3.2(a)

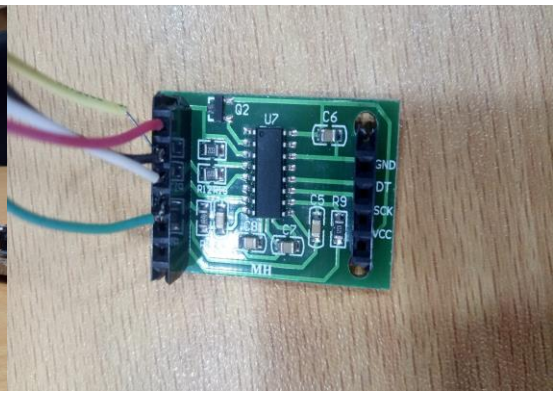

Figure 3.2(b)

Figure 3.2(c)

Figure 3.2(d)

Figure 3.2(a): Load Cell Sensor, Figure 3.2(b): HX711 Amplifier, Figure 3.2(c): Phase I Model A, Figure 3.2(d): Phase II Model B

3.3 Processing in Microcontroller:

The data which is obtained by the load cell sensors (figure 3.2.1) is now received by the microcontroller (Arduino). Arduino (figure 3.3) is basically connected with the Amplifier (figure 3.2.2), which helps in the amplification of the force signals. The clinical conditions have been assisted in the project, by the help of quantitative values we are able to know the different conditions of the genomic aged and osteoporotic diseases. Volunteer section is also very helpful for getting the different types of data, as we use healthy patients for the reference and standard values, while the disabled patients are used for getting the appropriate results and after that; analyzing it with the help of different conditions of physical and cognitive disabilities. Some conditions which have been given to the volunteers are: i) able to walk with the walker; ii) apply more force on the handle bar of the walker. The first condition is helpful for knowing the spatiotemporal gait parameters, while the second condition is used for the measuring of the different force levels.

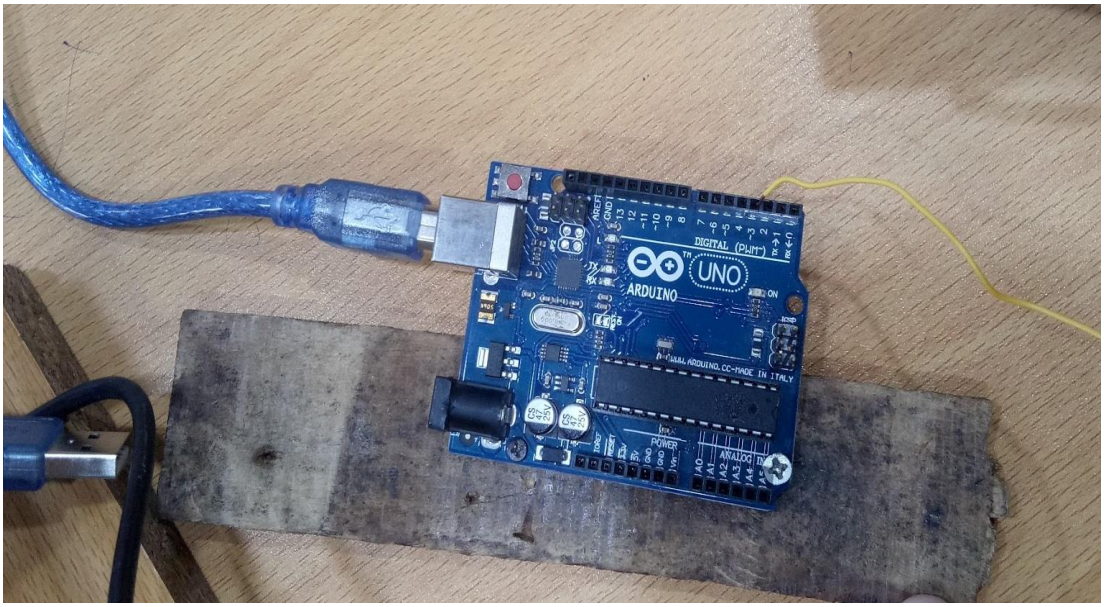

Figure 3.3: Arduino Uno (Microcontroller)

3.4 Transferring of Data:

Bluetooth is one of the main and popular wireless communications technologies, it uses as a low power consumption module. The main purpose of using Bluetooth is that it is easy to handle and it communicate Arduino (figure 3.3) properly and effectively. Transferring of the data is initially done by the help of USB port to make it possible to monitor data in serial plotter.

3.5 Pasco Capstone Force Sensors:

The Pasco capstone sensors are used for ~~taking~~ the input data in the form of force from the patient's upper limb. As the upper limb force is applied for moving the walker and performs the process of locomotion. When the volunteers of osteoporotic and genomic individuals apply force on the sensors which are connected in the walkers start measuring the force of the upper limbs and give output in the form of graphs.

3.6 Pasco Capstone Software:

~~Rehabilitation process is usually depending on the patient's conditions, neurological diseases and several other amputee problems are usually inter connected with the slowest gait. The patients are usually not able to walk properly due to their disorders. So due to these major problems the results will vary according to their conditions.~~ The results which are obtained are shown in the form of graphs and the value which fluctuate and shifts in the graphs shown the problem in the patient's lower limb. Several outputs have been obtained by the genomic and the osteoporotic patients. Furthermore, we provide them two different conditions for the gathering of more accurate results (as it mention in 3.3 of methodology). One more thing which we have notice that, the patients those who suffer from lower limb amputee or different types of factures have more different and difficult gait parameters, and these results has been taken in the form of graphs. The Pasco software has been used for the interpretations and the analysis of the outputs.

3.7 Mechanical Assembly and Development of Pre-phase and Phase 1 Models:

The mechanical design of the walking aid consists of the several different major components, which includes, load cell sensor, Pasco force sensors, Arduino, blue tooth module and the Pasco capstone software. The walking aid is specially designed for the analysis of the gait parameters and osteoporotic patients force of upper limbs used for movement, as it helps to give results about the potential fails of health in future and problems of the patients in walking[12]. This walker has integrated force sensors which helps in getting ~~appropriate~~ ~~results~~ and it also prevent patients from wearing any sensors. As we have discussed above in the chapter ~~no.~~1 that the walker does not contain any type of neither wearable sensors nor any cameras for monitoring. So it's a main challenge ~~for us~~ to design ~~that~~ particular and user friendly device that helps in the analysis of the spatiotemporal gait.

3.7.1 Mechanical Assembly and Development of Pre-phase

For the development of the walking aid in pre-phase, we used load cell sensors, which will be connected to the Arduino by the help of amplifier and after that Arduino with the blue tooth module. The main purpose for this whole work is to predict and analysis the working of the load bar sensors to understand that how will we are able to design new prototype. This initial prototype is designed by the help Arduino, which shows the results in the form of digits and the initial results are obtained in the serial plotter. The Bluetooth module or wireless is a hardware component; they are working on the radio waves connecting the cable of the computer.

3.7.2 Mechanical Assembly and Development of Phase I Model A:

Now for the development of the Phase 1 model A and B, the walking aid [13] i.e. walker is used, we took four Pasco load sensors and fixed them on the rods of the walker by cutting the rods with the distance of 5mm. After the cutting and placing of the sensors, we connected the sensors with the interfacing

device of the capstone. Because of the placement of the four sensors we have gain the very accurate results. When the patient grabs the handle they apply force on them and the sensor starts taking the reading of the upper limb extremity forces. These load sensors are linked with the amplifier, as amplifier amplify the signals and then pass it on to the Pasco capstone software. The load bearing of the load sensors are the 100N each. The fixing of the sensors is very delicately completed and all the feasibility of the disables patients is within under consideration, at the time of fixation in the walker because the walker is planned to be used for the long term purpose in the daily life. The placement of the sensors in the model A is un equally distributed, so because of that 19% error has been generated, now to overcome this problem; the model B has been planned to design.

3.7.3 Mechanical Assembly and Development of Phase I Model B:

In Phase I Model B, there are same components used as that of those used in Phase I Model A. A prototype was designed on solid works to develop the Phase I Model B. All the sensors are placed at the same positions on the legs of the walking frame. The Model B is the final prototype of the walking aid, which is used in the research work and data collection of final year project.

3.8 System Layout:

Walkers are a useful support for Activities of Daily Living (ADL) [13] in users with mobility challenges. Walker contains a light weight body structure that equips the patient to be friendlier towards it and gives a sense of comfort while walking.

This walker has integrated sensors that may spare the user from the burden of wearable, by placing the four force sensors on the paddle rod bars, the pressure applied by the patient is measured through these sensors and then that information is transferred to the software. Monitoring of parameters like step time or weight-bearing can be for the diagnostic support, evaluation of progress or risk prediction [13].

In pre-phase model the strain gauge is placed in the load cell sensor; through which, we would be able to tell just how heavy an object is, if the weight of

object changes over time, or if we simply need to sense the presence of an object by measuring strain or load applied to a surface. While the same principle is applicable for the Pasco load cell sensors.

In Pre-Phase, to extract the measurable data out from a load cell and strain gauge; we use HX711 Load Cell Amplifier. The amplifier accepts five wires from the load cell and the wires are identified with colors; red, black, white, green, and yellow. These colors correlate on the basis of color coding of load cells, where red, black, green and white wires come from the strain gauge on the load cell and the optional ground wire is yellow that is not hooked up to the strain gauge because there is no need to ground any tiny outside electromagnetic interference (EMI).

The interfacing of the Arduino with force sensor and Bluetooth module (figure 3.4), is demonstrated clearly with the pin configuration. The digital pins 2 and 3 of Arduino are connected to the DT and SCK of the amplifier HX711 respectively. The 5V pin of the Arduino is connected to the VCC pin of the amplifier HX711 and GND pin of the Arduino is connected to the GND pin of the amplifier HX711. Red wire of the load sensor is connected to the E+, black wire is connected to E, green wire is connected to A and the white wire is connected to the A+ of the amplifier HX711. The laptop which we are using in the project, which is of Dell company, have the capacity of 2GB RAM and have the storage capacity of 250GB in hard disc, and the core of the laptop is i3. The laptop screen shows the result of the work of the project.

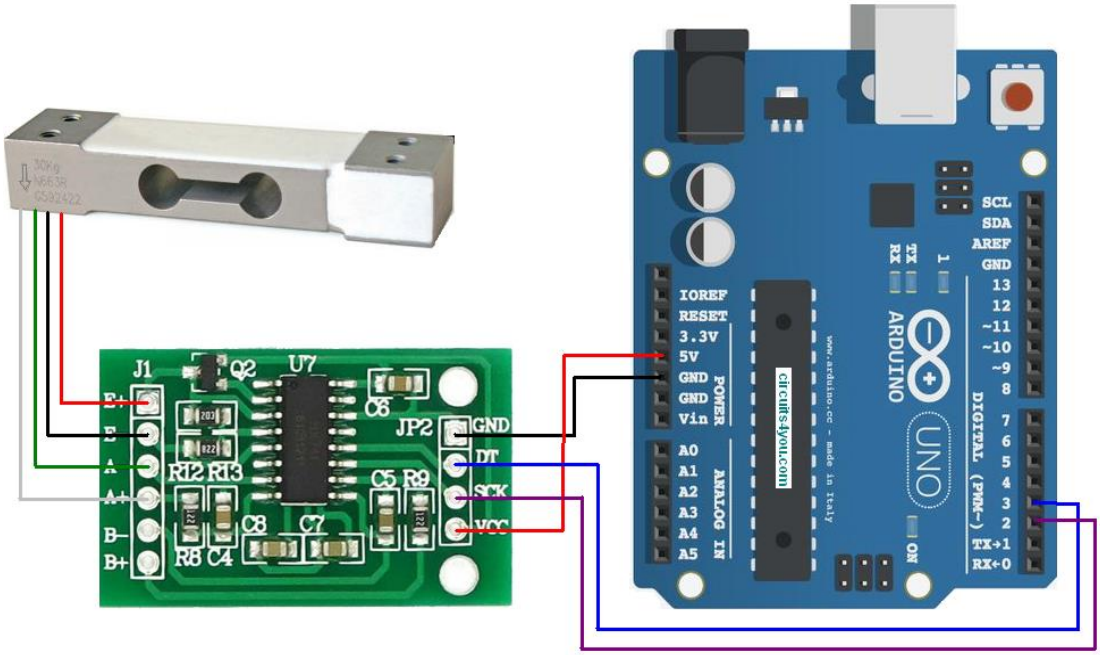

Figure 3.8: Circuit Layout [3] (Reprinted)

3.9 Flow Chart:

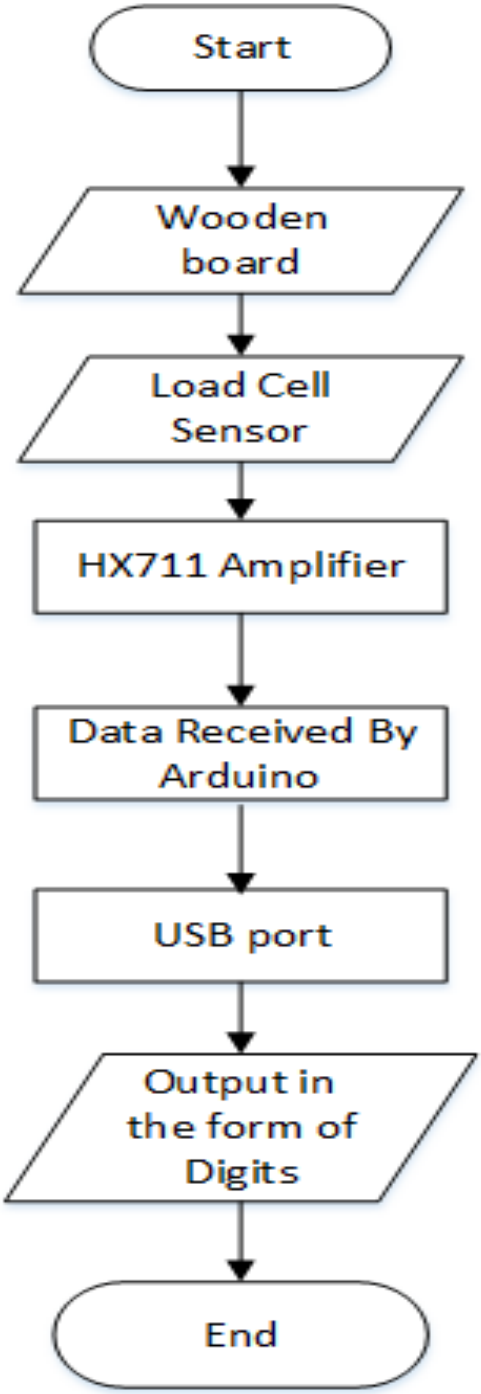

Figure 3.9.1: Flow Chart of Pre-Phase Model Figure

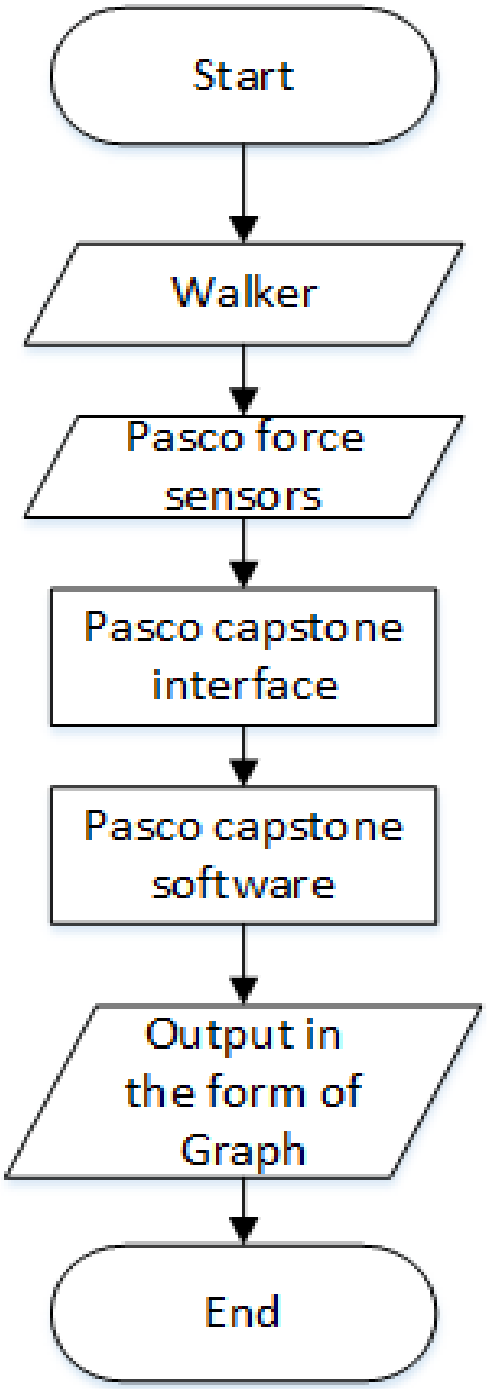

Figure 3.9.2: Flow Chart of Phase model A and B

CHAPTER 4

RESULTS AND DISCUSSION

CHAPTER 4 - RESULTS AND DISCUSSION

4.1 Introduction:

The mechanism used to ~~draw~~ results of the forces applied on each sensor is through the Pasco Capstone software. Each load cell sensors had been placed on each leg of the static walker and each sensor bears 100N force; which are able to detect force and motion applied by the subject. The testing was done through two main experimentation methods i.e. the placement of load cell sensor on unequal positions and equal position. The experiments performed were actually to carry on the research further and to see clear results. Testing is the crucial part of this project because it's a research based project.

4.2 Experiment:

The experiment is conducted over total 40 volunteers in which include two sets of group of people. One is genomic aged volunteer's i.e. 20 in total and other set include osteoporotic volunteers i.e 20 in numbers. The results which obtain are very much accurate as compare to the previous research papers of Lower limb disabilities [12,13]. In previous researches, only the 12 to 20 volunteers have been taken and they work only the spatiotemporal gait parameters. While in this research paper we work on both the force of the upper limbs and the spatiotemporal gait parameters.

4.3 Phase I "Model A" Testing:

The testing was done on the walking frame having sensors placed on unequal positions. Testing was performed through the calibration of weights on each side of the walking frame i.e. one weight on right side including two sensors F1 & F3 and the other weight on the left side including two sensors F2 & F4. The error is calculated by hanging dumbbells of equal weight for comparing the readings of each side of the walker to measure the difference in forces applied on the walker.

The weights used for calibration were of 1kg, 2kg, 3kg, 4kg and 5kg. We obtained the error of 19% between the differences in readings of both the sides. The error was calculated by using the formula of percentage error. The error led us to the development of second model of our phase in which Pasco load cell sensors placed on equal positions on each leg of walking frame.

4.4 Phase I "Model B" Testing:

Pasco load cell sensors were placed on equal position on each leg of the walking frame to avoid any kind of error due to difference in readings of the forces measured. There was negligible error found in the model B of walking aid in which the forces were determined to analyze walking pattern. After satisfaction of obtaining desired results; the data collection of two groups of people was decided to be started to draw results of gait analysis parameters.

4.5 Experimental Setup:

The data collection was planned to pick up the subjects who are healthy and diseased; had been approached from a few towns of city Karachi. Pasco load cell sensors of 100N were used with the interfacing device of Pasco which interfaces the sensors to the Pasco Capstone software installed on the laptop of Dell company whose model is Inspiron Core i3. The walking frame of sensors placed on equal positions was carried to homes of subjects. The laptop was also carried which contains the Pasco capstone software.

The data of elderly people was decided to be collected who aged around 60 to 90 years. Data of healthy subjects was collected from their homes while the data of diseased patients was collected from 3 old homes named "Anmol Zindagi", "Gill Shelter Home" and "Gosha-e-Afiyat." The testing was first done in the rehabilitation center of Ziauddin University Faculty of Physical Therapy under the supervision of Dr. Amina Amir Khan (senior lecturer Ziauddin University Faculty of Physical Therapy) and Dr. Muhammad Asif (HOD of Ziauddin University Faculty of Engineering Science and technology). A physical therapist and a nurse were also present for guidance and service of the patient. A rehabilitation room with plain smooth tiled floor

was chosen to ask the subject for a walk on static walking frame. A subject was asked to walk for at least 10 steps but due to disability or aging issues there was the limit of 4 to 10 steps was set. First the patient was guided with the pattern to hold and walk for stability and safety of the patient. The walking time was estimated between 10 to 35 seconds due to differences in conditions of patients. The problem was diagnosed by the doctor and supervisors after the data collection of each patient.

4.6 Data Representation:

There are different forms of data representation of the subjects for achieving the desired and enhanced results. The following are the types of data representation of the data of forces collected:

- The raw data was collected in form of graphs on Pasco Capstone software present in the laptop.
- The details of subjects were written manually during the time of data collection which was later converted into a complete table after taking out some necessary readings by using formulas.
- The data of graphs was exported into text file to get the values of forces calculated on each moment of each second of the patients walk.
- The data was also exported the form of sheets on MS. Excel to create the combined graph representation of desired way.

The data of forces applied by the subjects is collected in the form of graphs which show the peaks. Force measured by the load cell sensor is represented on four individual graphs of four sensors. When a subject start to take a step then the force is applied on both the handles of the walking frame so force is distributed on each leg of the walker containing each sensor due to which a peak starts to generate on each graph. When the person ends taking the step then the force is decreased and the peak drops to minimum or may be negative value. The x axis contains the time while forces are present on y axis. Each

force is represented with different color for analyzing the difference to drive some useful conclusions.

4.7 Data Graphs and Analysis of Healthy Subjects:

The 20 figures with two parts (a) and (b) contain the graphs of healthy subjects in which the first part is the graphical representation of the four forces applied on each leg of the walking frame while the second part is the graphical representation of sum of two forces applied on each side of the walking frame. The analysis of data of all healthy subjects is performed individually which is mentioned with details along with the table of data collected of each subject.

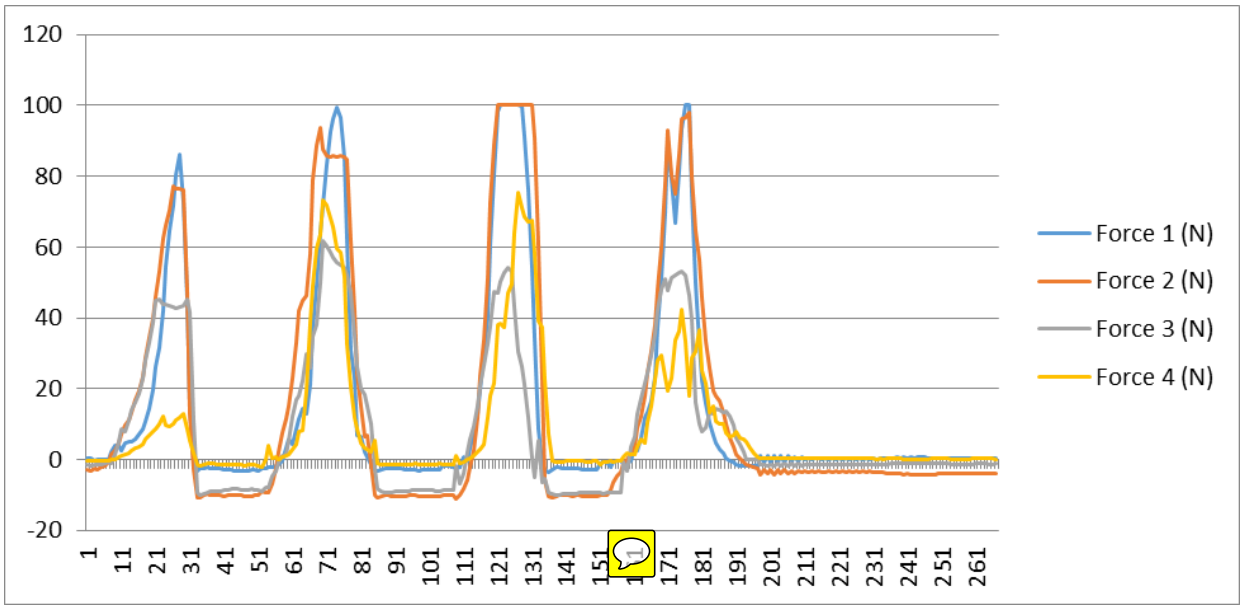

Figure 4.7.1(a): Graph of four forces of Subject I

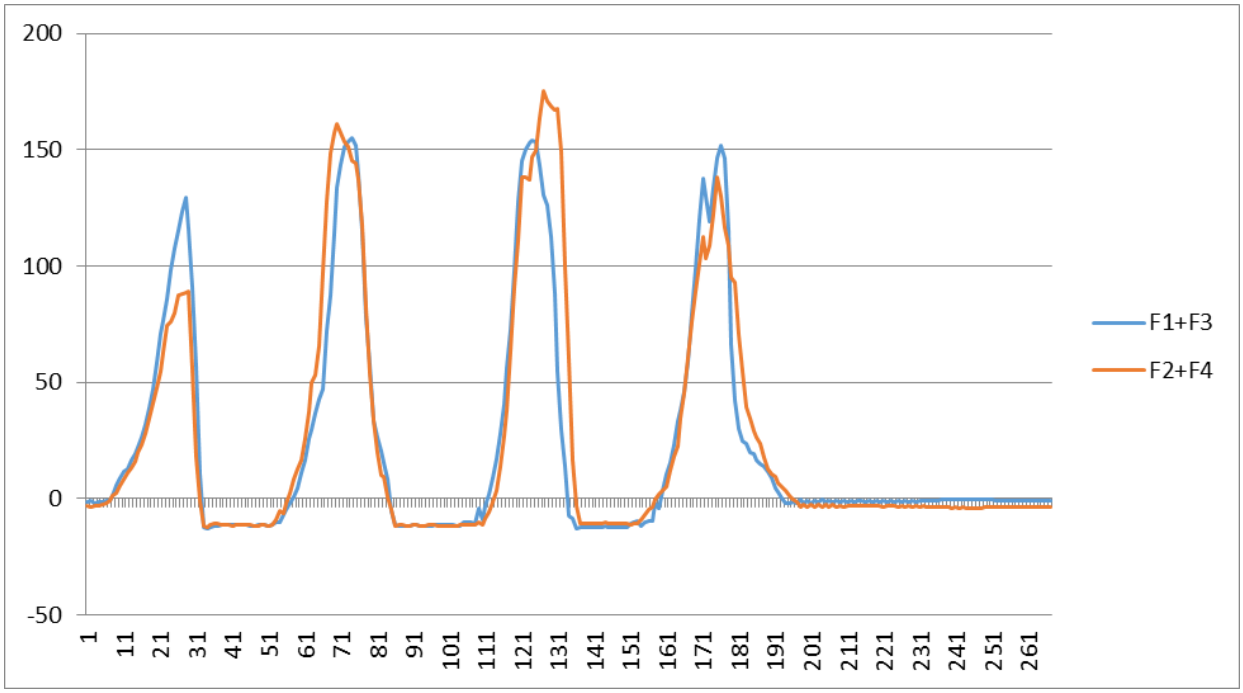

Figure 4.7.1(b): Graph of sum of two forces of Subject I

Table 4.7.1: Data of Subject I

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Step	Time (sec)	Right to left step length (in)	Left to right step length (in)	Stride Length (inch)	Condition
1	63	77	6’’7	18.5	06	16	17.2	21	38.2	Normal Genomic

4.7.1 Analysis:

The rise and fall of forces in graph shows upper limb forces during handling of static walker used for gate by healthy genomic individual. At first F1 rises up to 83N of force, F2 rises to 78N of force similarly F3 rises up to 43N and F4 up to 10N of force. The values of four forces changes differently from person to person because it depends on strength of muscle, age, BMI of subject. The results are quite different form individuals with osteoporosis, prosthetics and orthotics. Patient is taken as a subject to study walking pattern he is not an osteoporotic patient but due to his elder age and underweight his muscle strength is weak that why he applies more force to move forward due to maximum force he get tired early and not able to take steps more than 4. Hence, it is proved that force is inversely proportional to velocity.

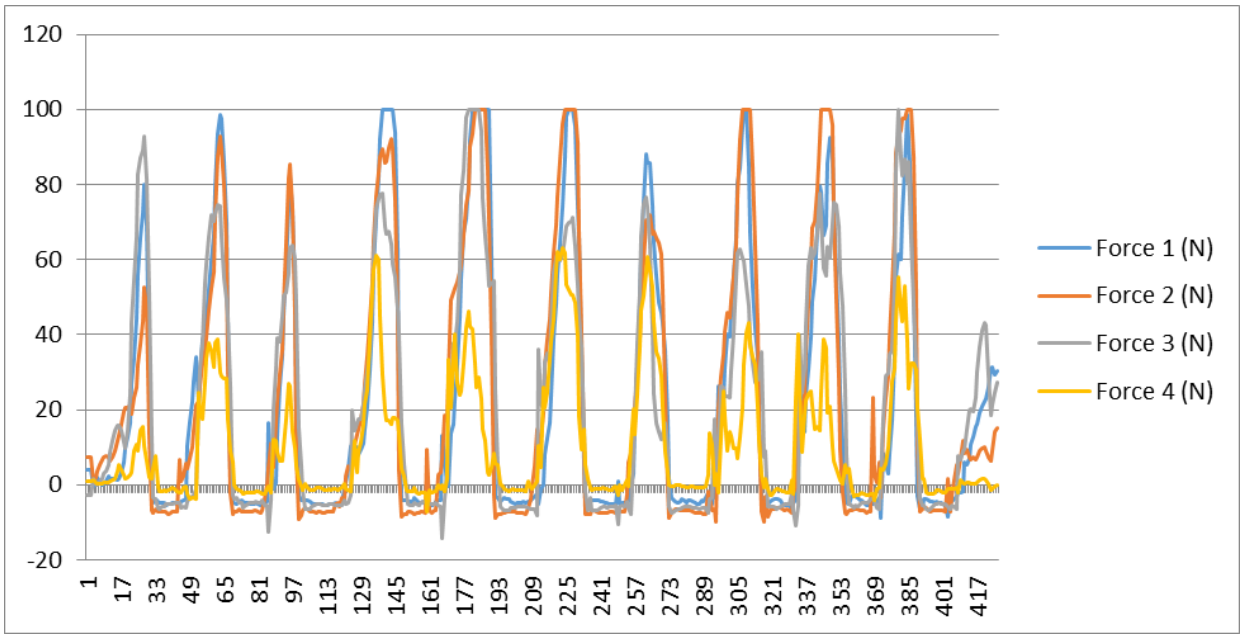

Figure 4.7.2(a): Graph of four forces of Subject II

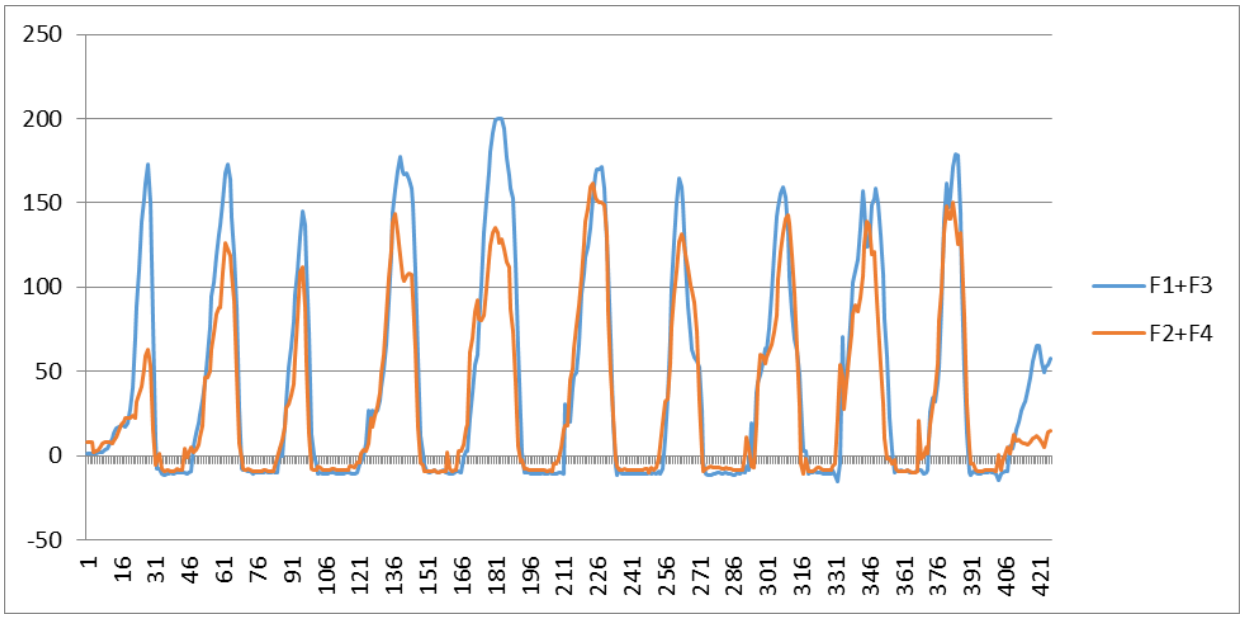

Figure 4.7.2(b): Graph of sum of two forces of Subject II

Table 4.7.2: Data of Subject II

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Step	Time (sec)	Right to left step length (in)	Left to right step length (in)	Stride Length (inch)	Condition
2	74	66	5”6	23.4	10	19	19.5	22.2	41.7	Normal Genomic

4.7.2 Analysis:

The rise and drop of strengths in chart appears upper limb strengths amid taking care of inactive walker utilized for gate by healthy genomic person. At first F1 rises up to 80N of drive, F2 rises to 56N of force similarly F3 rises up to 96N and F4 up to 17N of force. The values of four powers changes differently from individual to individual since it depends on strength of muscle, age, BMI of subject. The force comes about are very diverse form people with osteoporosis, prosthetics and orthotics. Patient is taken as a subject to consider strolling design he isn't an osteoporotic patient but due to his senior age and beneath weight his muscle strength is powerless that’s why he applies more drive to move forward. Subsequently, it is demonstrated that force is inversely proportional to speed.

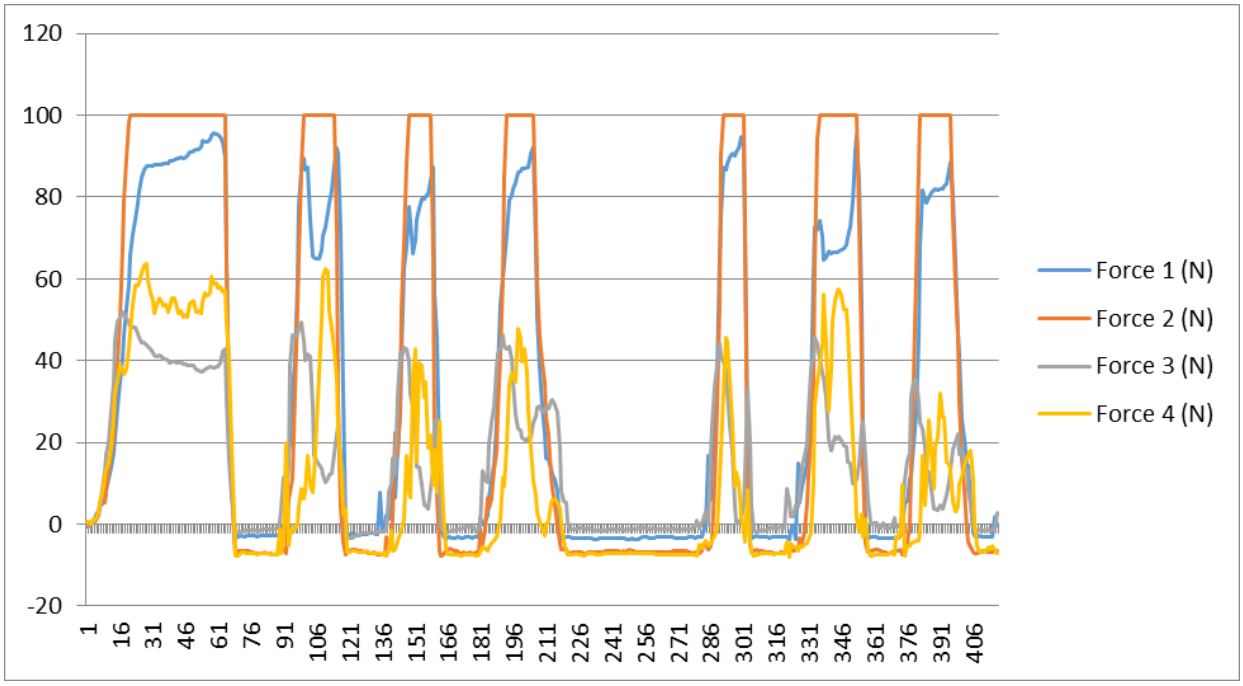

Figure 4.7.3(a): Graph of four forces of Subject III

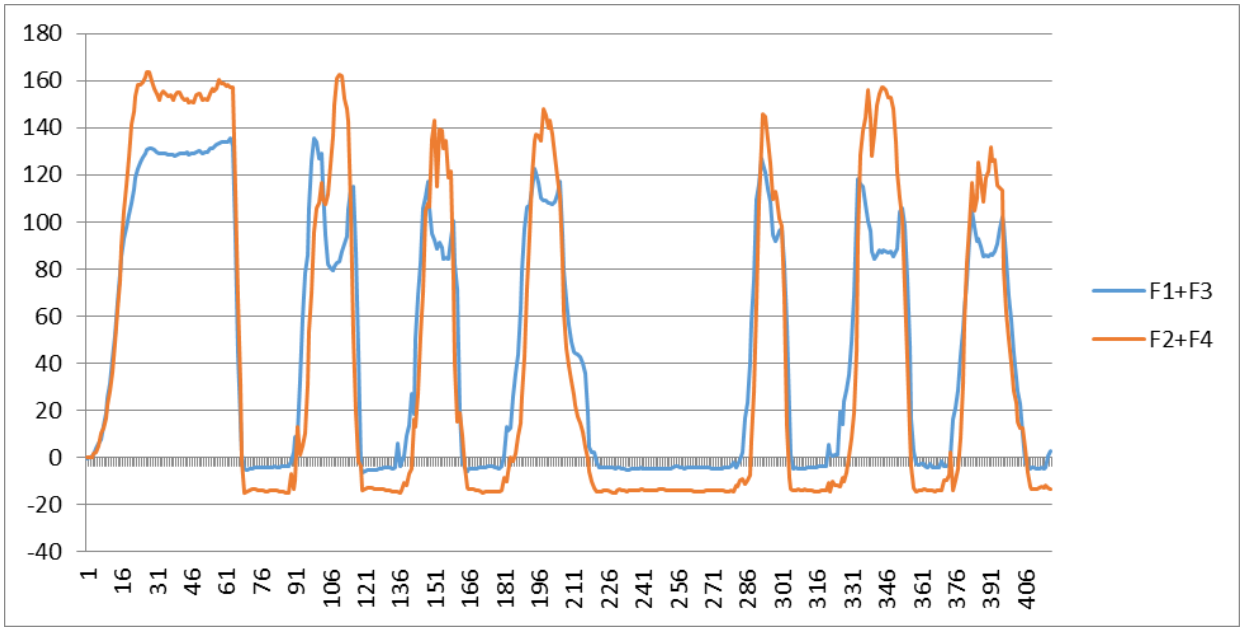

Figure 4.7.3(b): Graph of sum of two forces of Subject III

Table 4.7.3: Data of Subject III

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Step	Time (sec)	Right to left step length (in)	Left to right step length (in)	Stride Length (inch)	Condition
3	74	66	5”6	22.6	07	17	21	19.5	40.5	Normal Genomic

4.7.3 Analysis:

The rise and drop of strengths in chart appears upper limb strengths amid taking care of inactive walker utilized for gate by healthy genomic person. At first F1 rises up to 98N of drive, F2 rises to 100N of force similarly F3 rises up to 50N and F4 up to 62N of force. The values of four powers changes differently from individual to individual since it depends on strength of muscle, age, BMI of subject. The comes about are very diverse form people with osteoporosis, prosthetics and orthotics. Patient is taken as a subject to consider strolling design he isn't an osteoporotic patient but due to his senior age and underweight his muscle strength is powerless that’s why he applies more drive to move forward. Subsequently demonstrated that force is inversely proportional to speed.

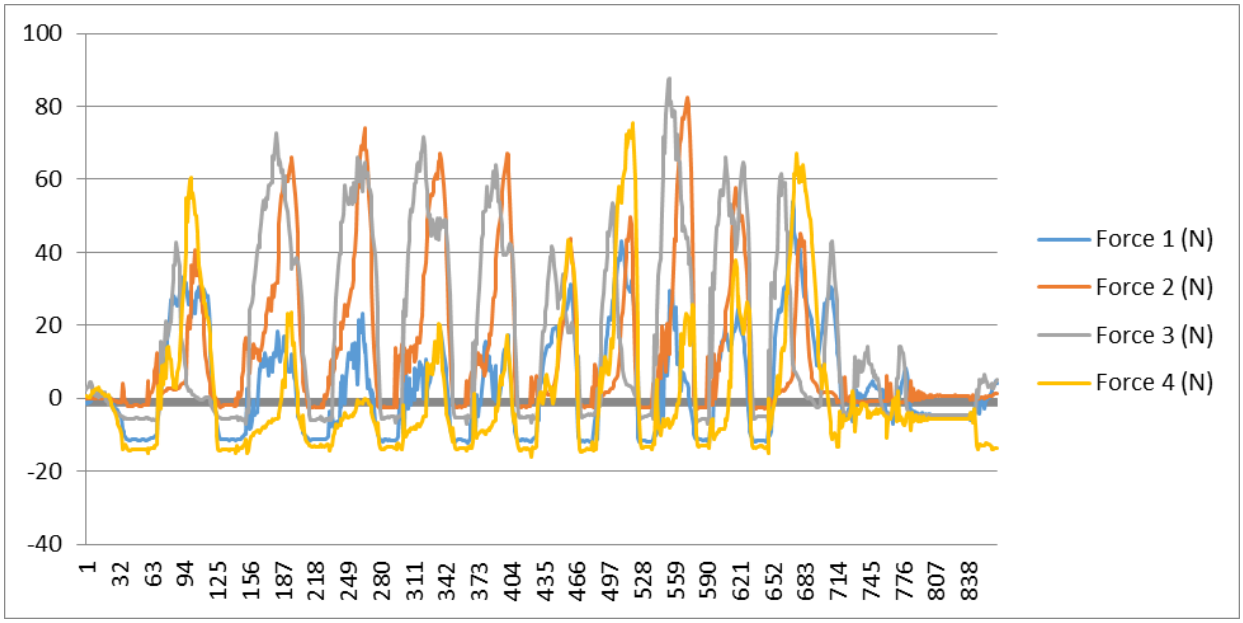

Figure 4.7.4(a): Graph of four forces of Subject IV

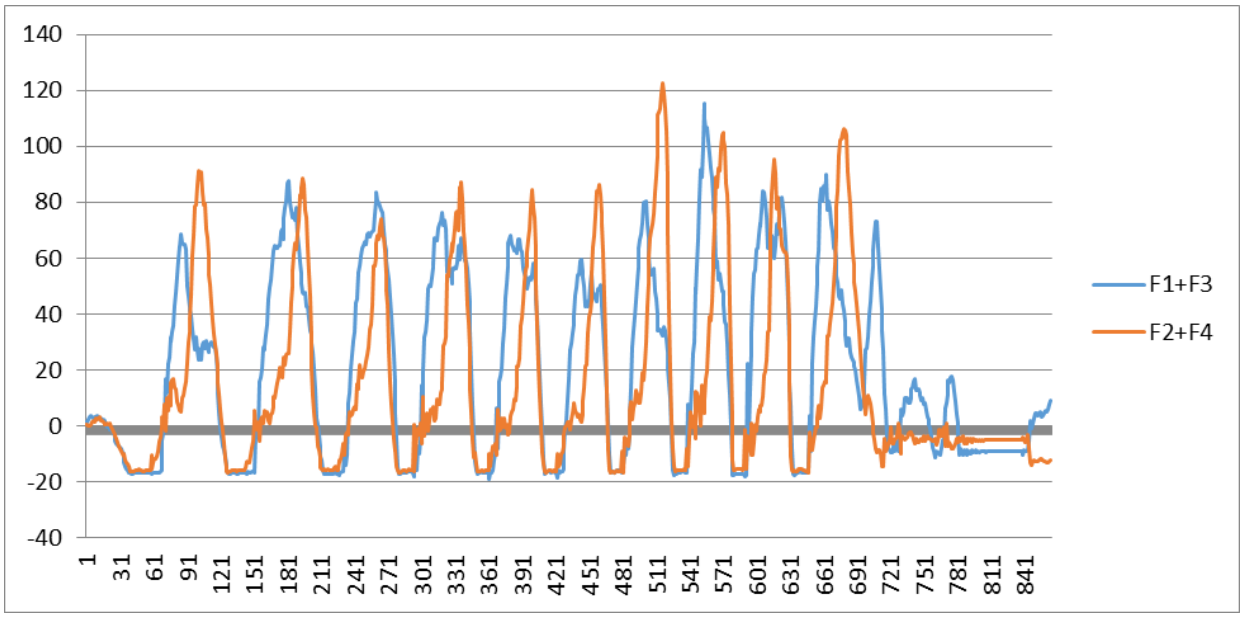

Figure 4.7.4(b): Graph of sum of two forces of Subject IV

Table 4.7.4: Data of Subject IV

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Step	Time (sec)	Right to left step length (in)	Left to right step length (in)	Stride Length (inch)	Condition
4	83	77	5”8	25.7	10	21	22.5	24.2	46.7	Normal Genomic

4.7.4 Analysis:

The rise and drop of strengths in chart appears upper limb strengths amid taking care of inactive walker utilized for gate by healthy genomic person. At first F1 rises up to 33N of drive, F2 rises to 40N of force similarly F3 rises up to 41N and F4 up to 60N of force. The values of four powers changes differently from individual to individual since it depends on strength of muscle, age, BMI of subject. The comes about are very diverse form people with osteoporosis, prosthetics and orthotics. Patient is taken as a subject to consider strolling design he isn't an osteoporotic patient but due to his senior age and underweight his muscle strength is powerless that’s why he applies more drive to move forward. Subsequently, it is demonstrated that force is inversely proportional to speed.

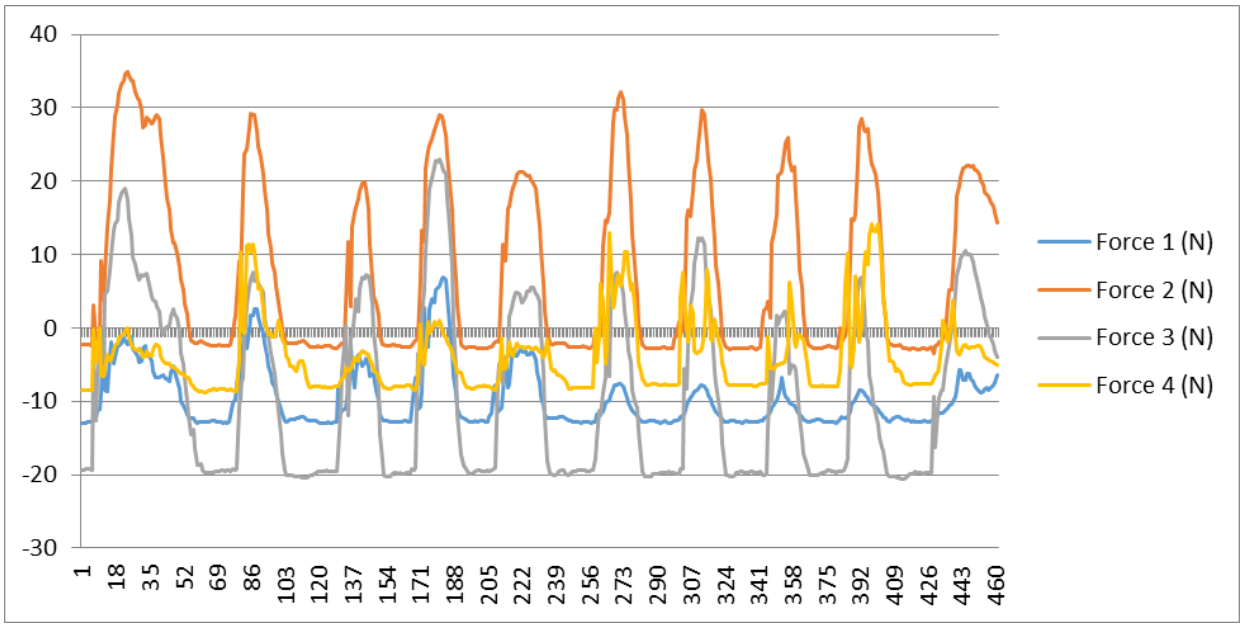

Figure 4.7.5(a): Graph of four forces of Subject V

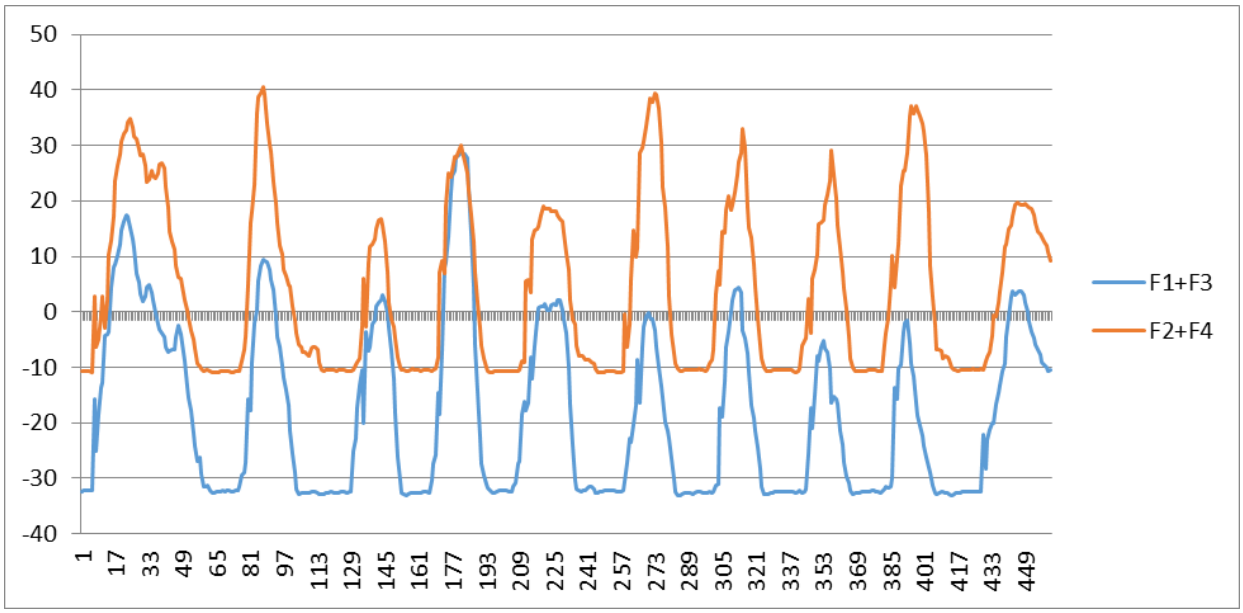

Figure 4.7.5(b): Graph of sum of two forces of Subject V

Table 4.7.5: Data of Subject V

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Step	Time (sec)	Right to left step length (in)	Left to right step length (in)	Stride Length (inch)	Condition
5	70	74	5	32	10	19	16.2	18	34.2	Normal Genomic

4.7.5 Analysis:

The rise and drop of strengths in chart appears upper limb strengths amid taking care of inactive walker utilized for gate by healthy genomic person. At first F1 rises up to 0N of drive, F2 rises to 35N of force similarly F3 rises up to 19N and F4 up to 12N of force. The values of four powers changes differently from individual to individual since it depends on strength of muscle, age, BMI of subject. There comes about are very diverse form people with osteoporosis, prosthetics and orthotics. Patient is taken as a subject to consider strolling design he isn't an osteoporotic patient but due to his senior age and underweight his muscle strength is powerless that’s why he applies more drive to move forward. Subsequently, it is demonstrated that force is inversely proportional to the speed.

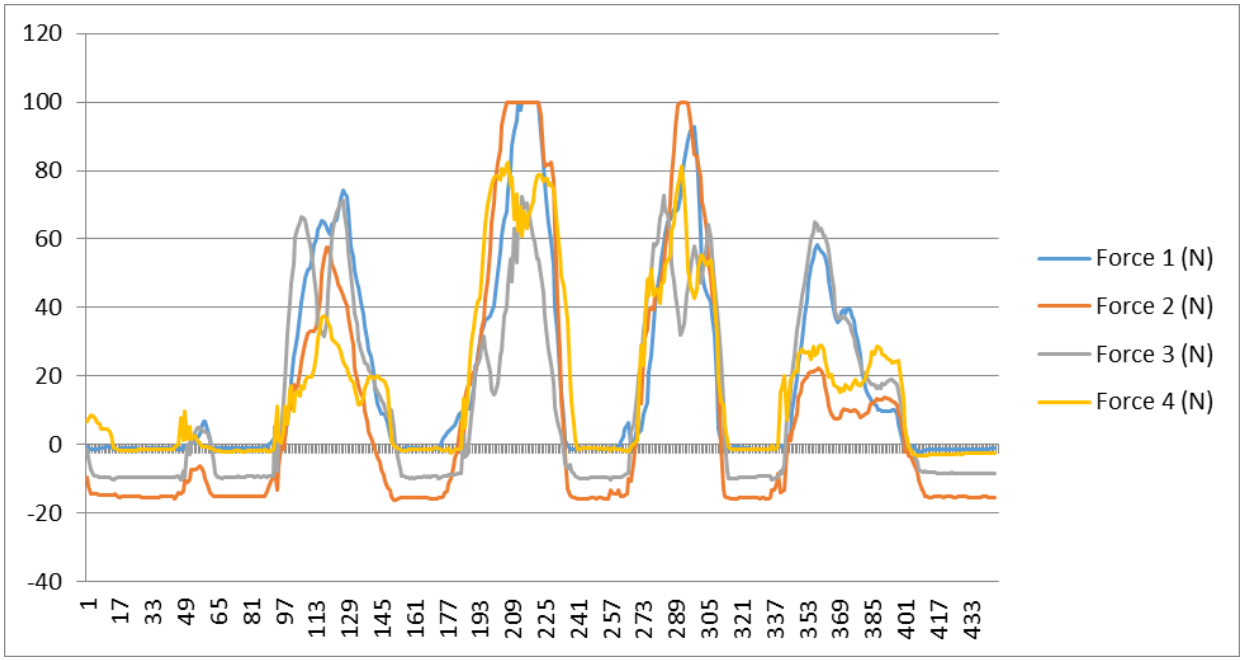

Figure 4.7.6(a): Graph of four forces of Subject VI

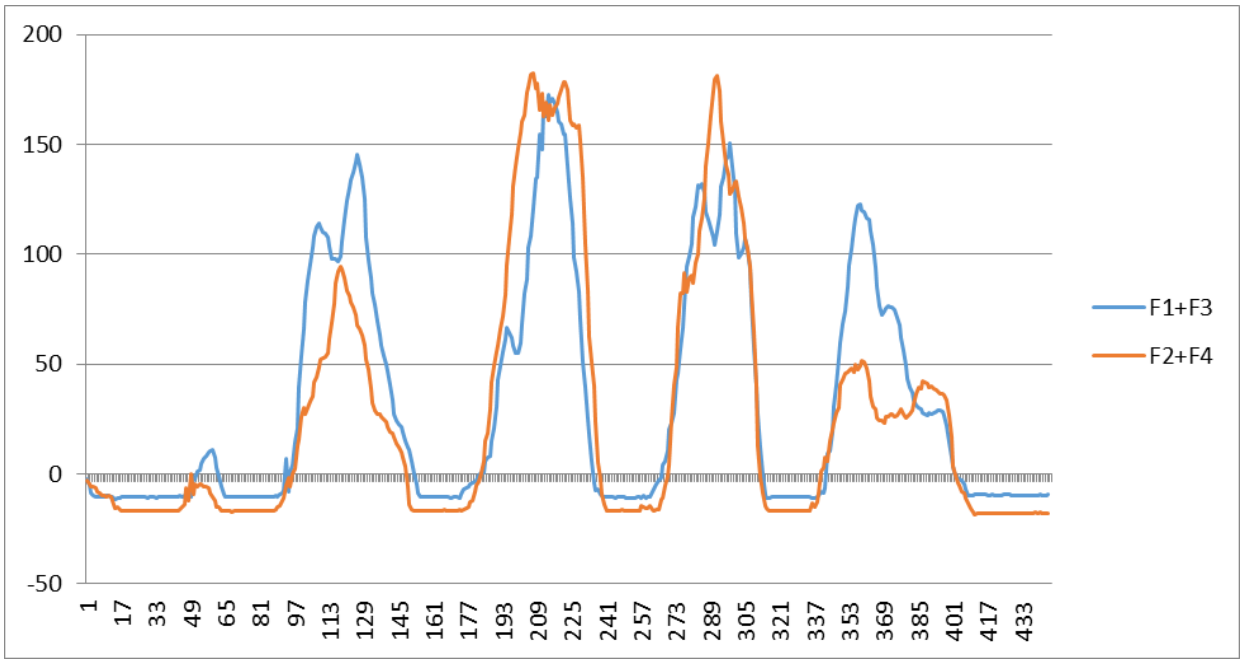

Figure 4.7.6(b): Graph of sum of two forces of Subject VI

Table 4.7.6: Data of Subject VI

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Step	Time (sec)	Right to left step length (in)	Left to right step length (in)	Stride Length (inch)	Condition
6	75	57	5”3	22.3	06	20	19	23.5	42.5	Normal Genomic

4.7.6 Analysis:

The rise and fall of forces in graph shows upper limb forces during handling of static walker used for gate by healthy genomic individual .At frist F1 rises upto 78N of force ,F2 rises to 59N of force similary F3 rises upto 78N and F4 upto 39N of force.The values of four forces changes diffrently from person to person because it depends on strenth of muscle,age,BMI of subject.The results are quite different form individuals with osteoporosis ,prosthetics and orthotics. Patient is taken as a subject to study walking pattern he is not an osteoporotic paptient but due to his elder age and under weight her muscle strength is weak that why she applies more force to to move forward. Hence proved that force is inversly propotional to velocity.

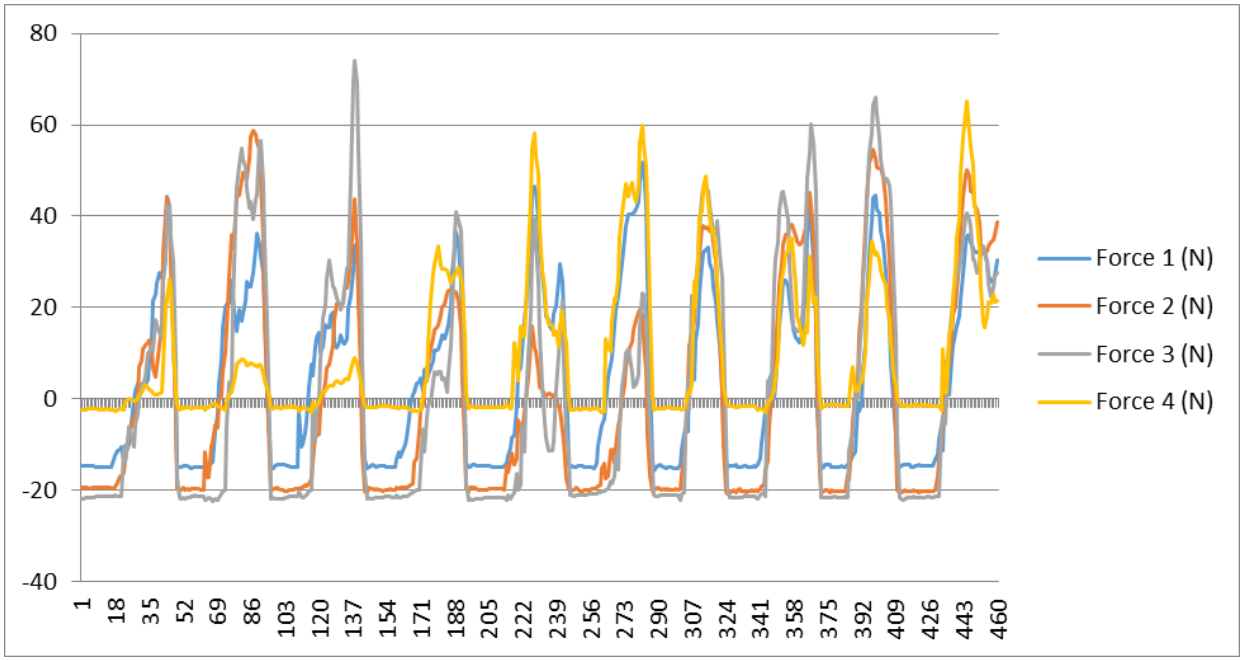

Figure 4.7.7(a): Graph of four forces of Subject VII

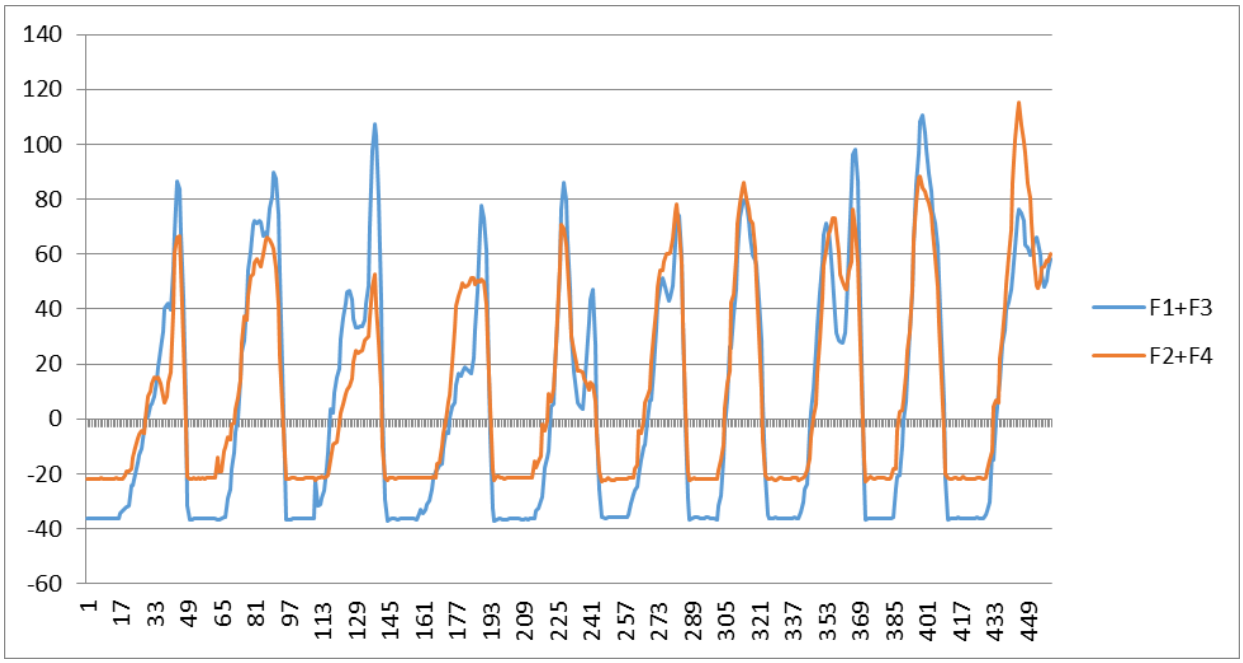

Figure 4.7.7(b): Graph of sum of two forces of Subject VII

Table 4.7.7: Data of Subject VII

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Step	Time (sec)	Right to left step length (in)	Left to right step length (in)	Stride Length (inch)	Condition
7	56	75	5”10	23.7	10	17	20.2	22.5	42.7	Normal Genomic

4.7.7 Analysis:

The rise and fall of forces in graph shows upper limb forces during handling of static walker used for gate by healthy genomic individual. At first F1 rises up to 30N of force, F2 rises to 44N of force similarly F3 rises up to 43N and F4 up to 28N of force. The values of four forces changes differently from person to person because it depends on strength of muscle, age, BMI of subject. The results are quite different form individuals with osteoporosis, prosthetics and orthotics. Patient is taken as a subject to study walking pattern he is not an osteoporotic patient but due to his elder age and underweight, his muscle strength is weak that why he applies more force to move forward. Hence, it is proved that force is inversely proportional to velocity.

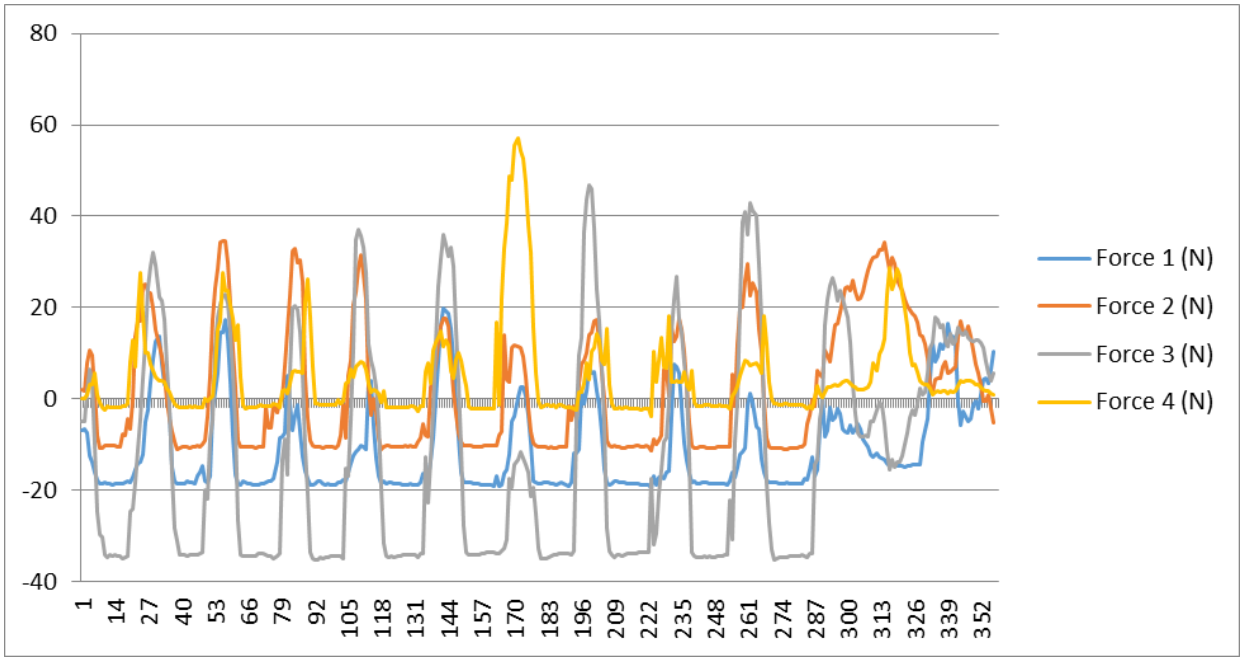

Figure 4.7.8(a): Graph of four forces of Subject VIII

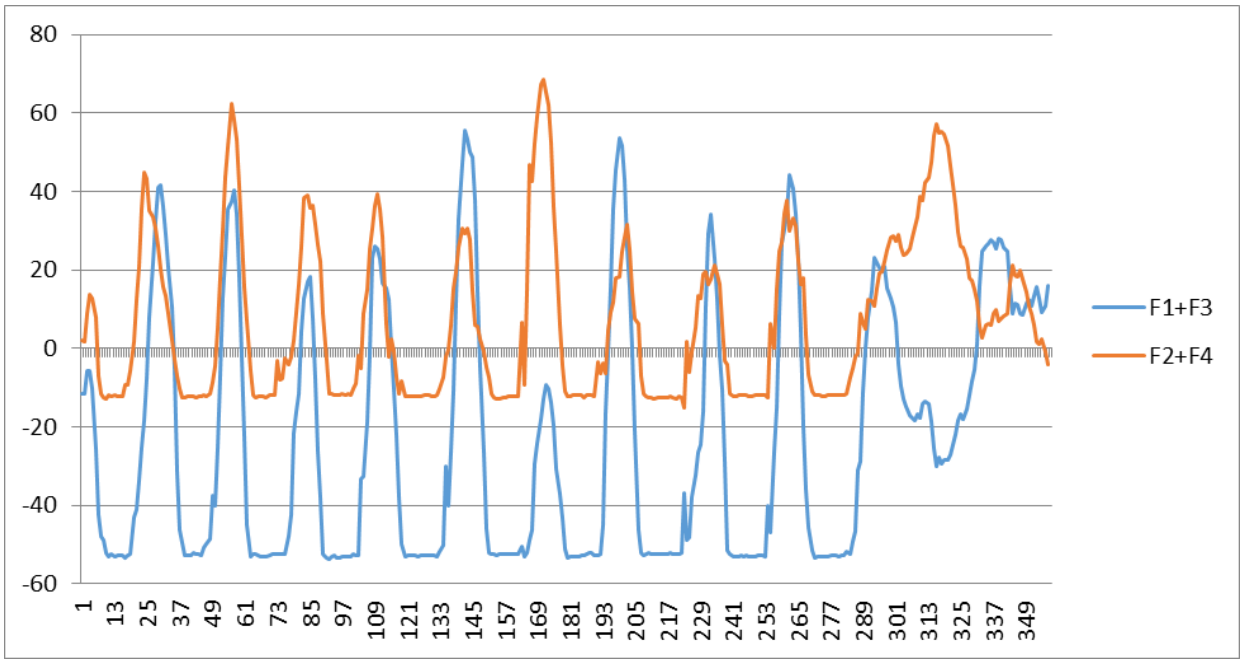

Figure 4.7.8(b): Graph of sum of two forces of Subject VIII

Table 4.7.8: Data of Subject VIII

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Step	Time (sec)	Right to left step length (in)	Left to right step length (in)	Stride Length (inch)	Condition
8	55	77	5”3	30.1	10	16	19.2	21	40.2	Normal Genomic

4.7.8 Analysis:

The rise and fall of forces in graph shows upper limb forces during handling of static walker used for gate by healthy genomic individual. At first F1 rises up to 17N of force, F2 rises to 25N of force similarly F3 rises up to 37N and F4 up to 28N of force. The values of four forces changes differently from person to person because it depends on strength of muscle, age, BMI of subject. The results are quite different form individuals with osteoporosis, prosthetics and orthotics. Patient is taken as a subject to study walking pattern she is not an osteoporotic patient but due to his elder age and underweight, her muscle strength is weak that why she applies more force to move forward. Hence, it is proved that force is inversely proportional to velocity.

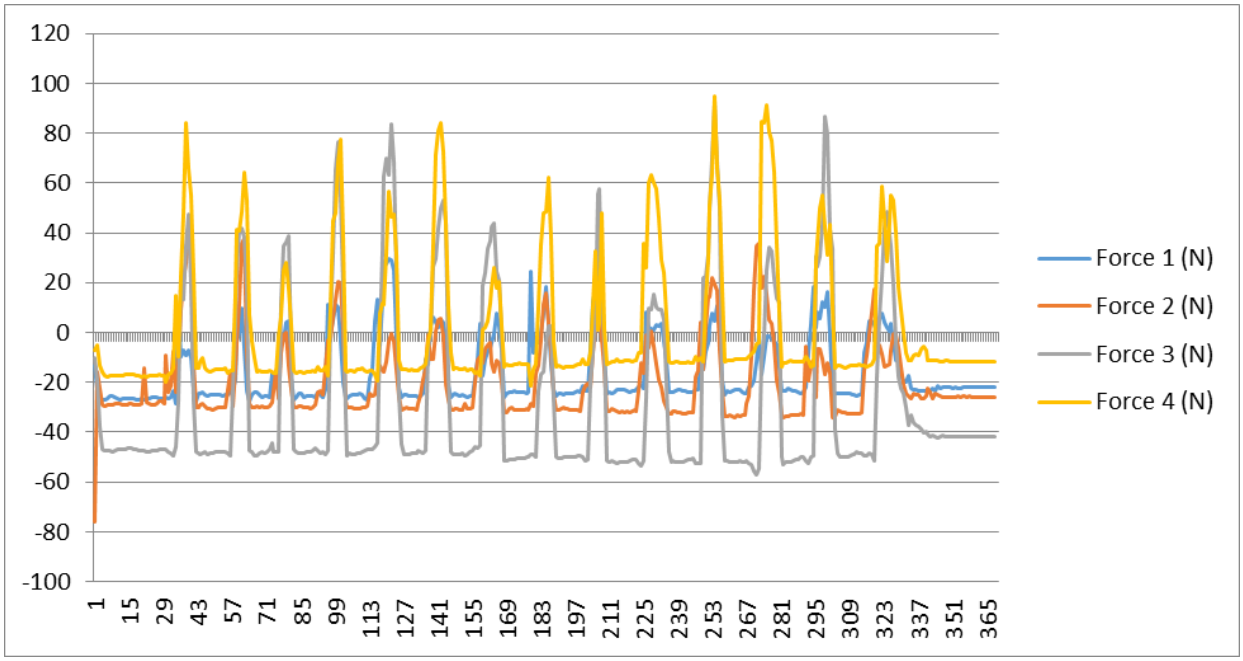

Figure 4.7.9(a): Graph of four forces of Subject IX

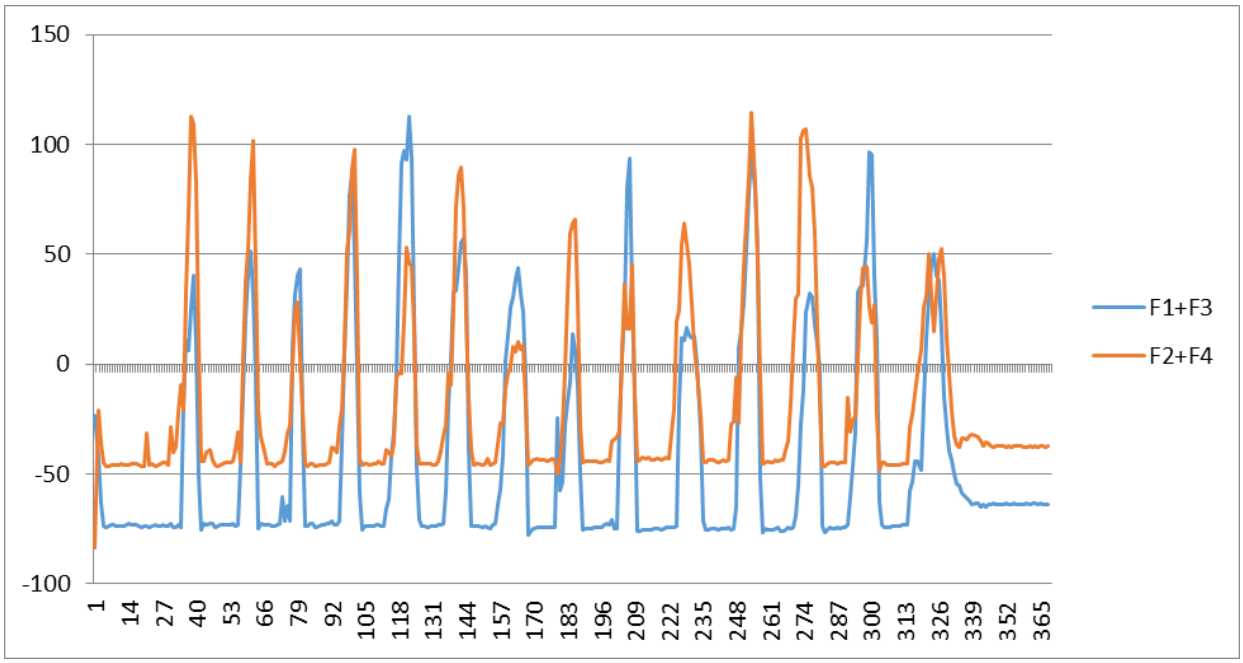

Figure 4.7.9(b): Graph of sum of two forces of Subject IX

Table 4.7.9: Data of Subject IX

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Step	Time (sec)	Right to left step length (in)	Left to right step length (in)	Stride Length (inch)	Condition
9	87	41	4”11	18.2	10	20	17	18.5	35.5	Normal Genomic

4.7.9 Analysis:

The rise and fall of forces in graph shows upper limb forces during handling of static walker used for gate by healthy genomic individual .At frist F1 rises upto 45N of force ,F2 rises to 40N of force similary F3 rises upto 45N and F4 upto 83N of force.The values of four forces changes diffrently from person to person because it depends on strenth of muscle,age,BMI of subject.The results are quite different form individuals with osteoporosis ,prosthetics and orthotics. Patient is taken as a subject to study walking pattern he is not an osteoporotic paptient but due to his elder age and under weight he muscle strength is weak that why he applies more force to to move forward. Hence proved that force is inversly propotional to velocity.

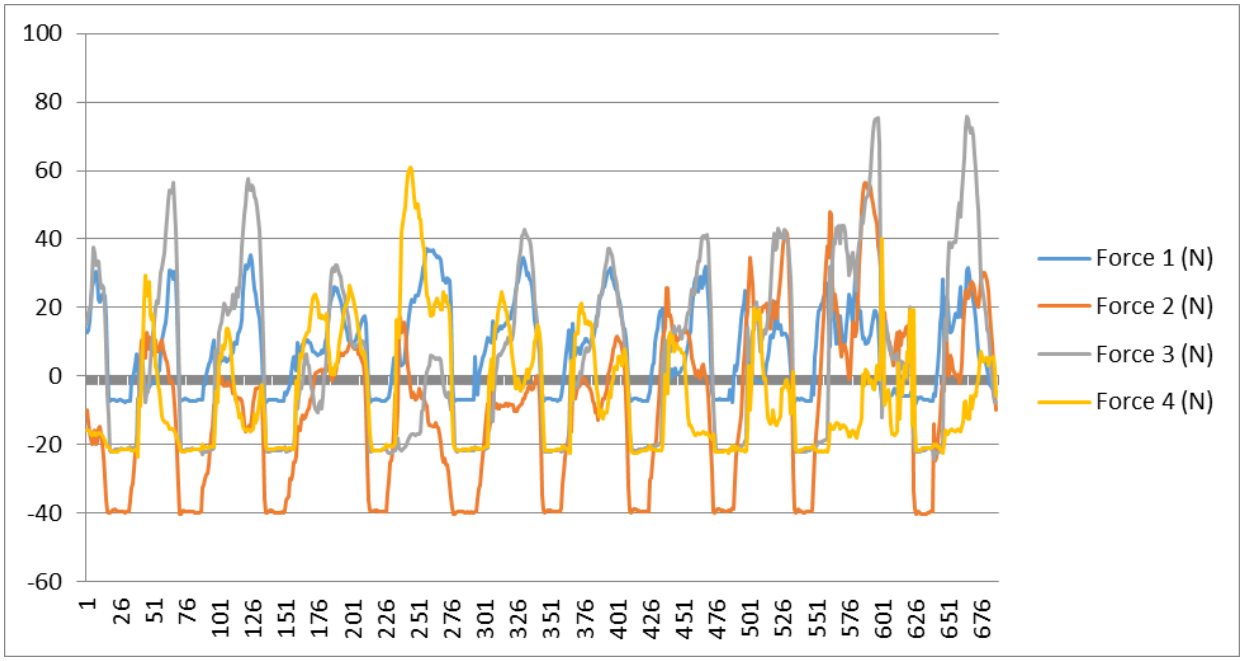

Figure 4.7.10(a): Graph of four forces of Subject X

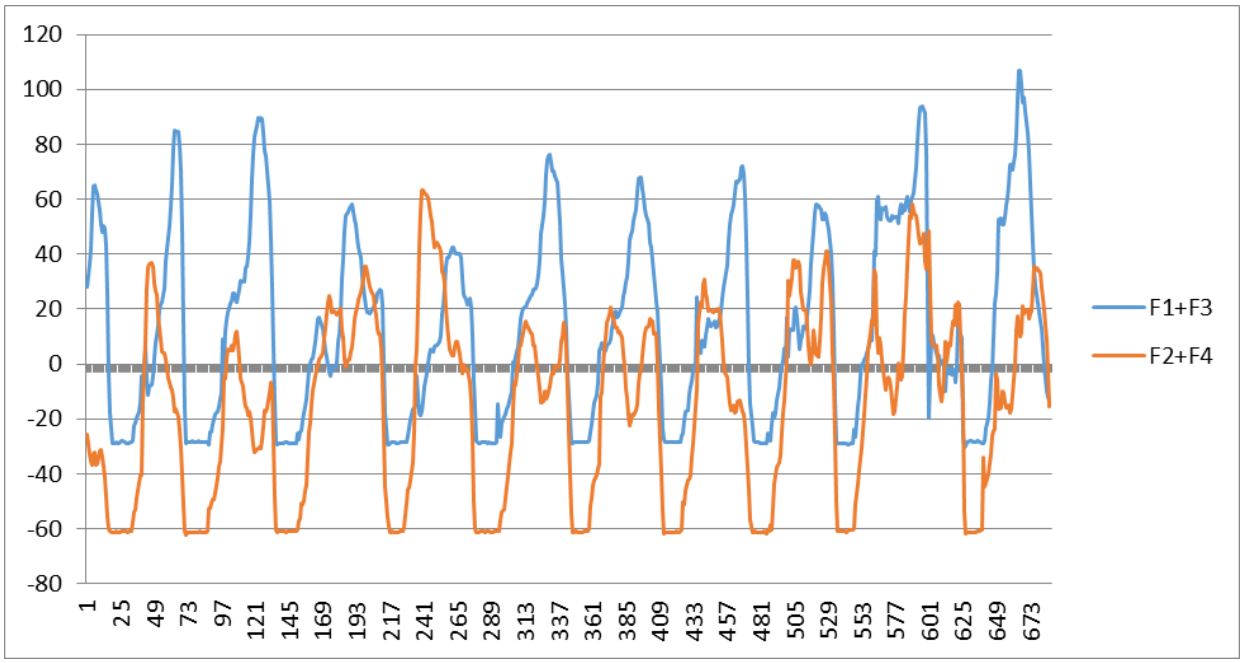

Figure 4.7.10(b): Graph of sum of two forces of Subject X

Table 4.7.10: Data of Subject X

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Step	Time (sec)	Right to left step length (in)	Left to right step length (in)	Stride Length (inch)	Condition
10	85	61	5”2	24.7	10	19	16.5	17.2	33.7	Normal Genomic

4.7.10 Analysis:

The rise and fall of forces in graph shows upper limb forces during handling of static walker used for gate by healthy genomic individual .At frist F1 rises upto 30N of force ,F2 rises to 15N of force similary F3 rises upto 59N and F4 upto 30N of force.The values of four forces changes diffrently from person to person because it depends on strenth of muscle,age,BMI of subject.The results are quite different form individuals with osteoporosis ,prosthetics and orthotics. Patient is taken as a subject to study walking pattern he is not an osteoporotic paptient but due to his elder age and under weight he muscle strength is weak that why he applies more force to to move forward. Hence, it is proved that force is inversly propotional to velocity.

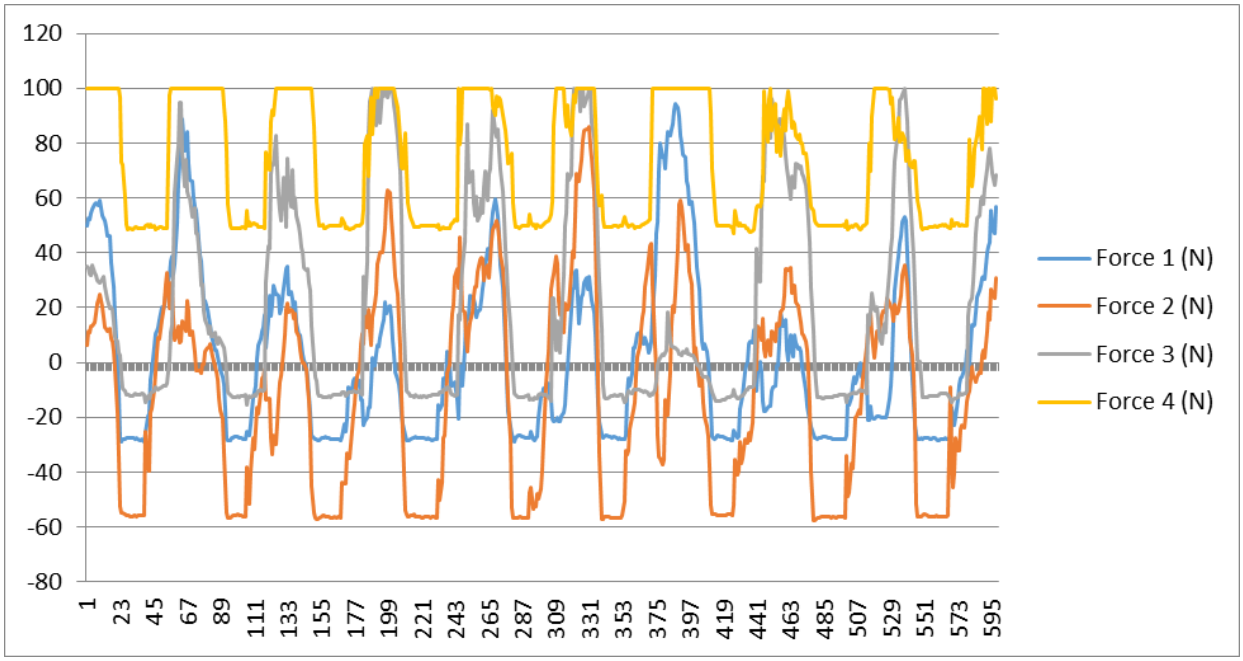

Figure 4.7.11(a): Graph of four forces of Subject XI

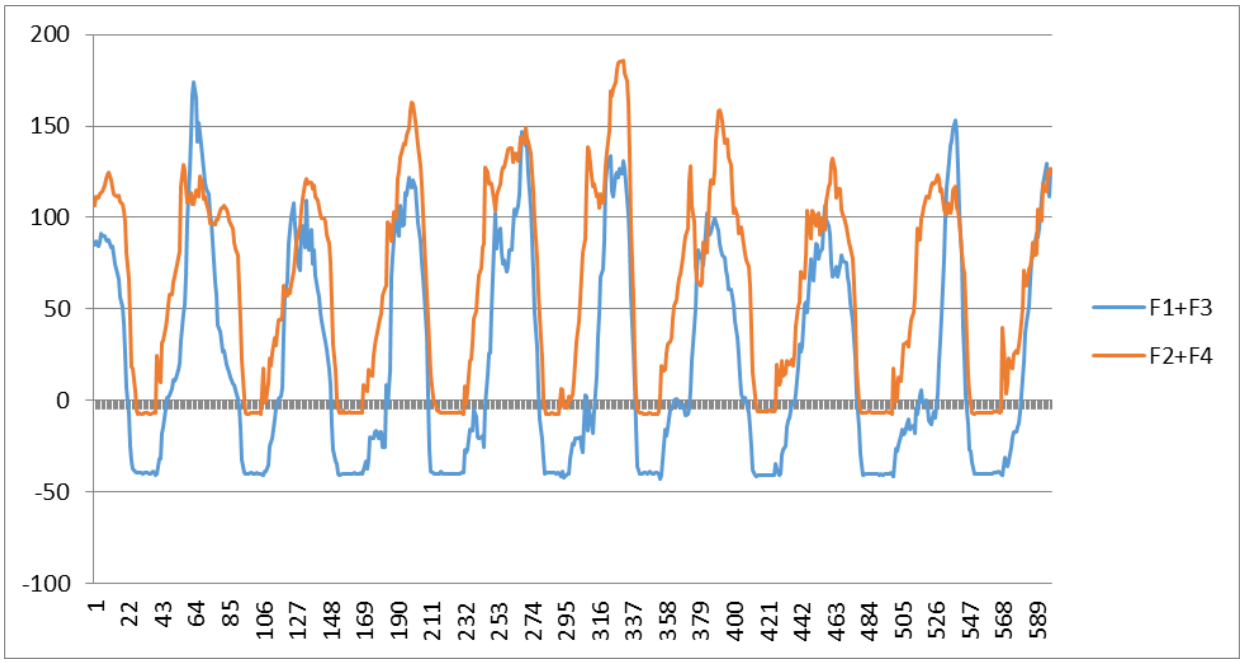

Figure 4.7.11(b): Graph of sum of two forces of Subject XI

Table 4.7.11: Data of Subject XI

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Step	Time (sec)	Right to left step length (in)	Left to right step length (in)	Stride Length (inch)	Condition
11	66	56	5”6	19.8	09	18	22	20.5	42.5	Normal Genomic

4.7.11 Analysis:

The rise and fall of forces in graph shows upper limb forces during handling of static walker used for gate by healthy genomic individual .At frist F1 rises upto 84N of force ,F2 rises to 38N of force similary F3 rises upto 98N and F4 upto 100N of force.The values of four forces changes diffrently from person to person because it depends on strenth of muscle,age,BMI of subject.The results are quite different form individuals with osteoporosis ,prosthetics and orthotics. Patient is taken as a subject to study walking pattern she is not an osteoporotic paptient. Hence, its proved that force is inversly propotional to velocity.

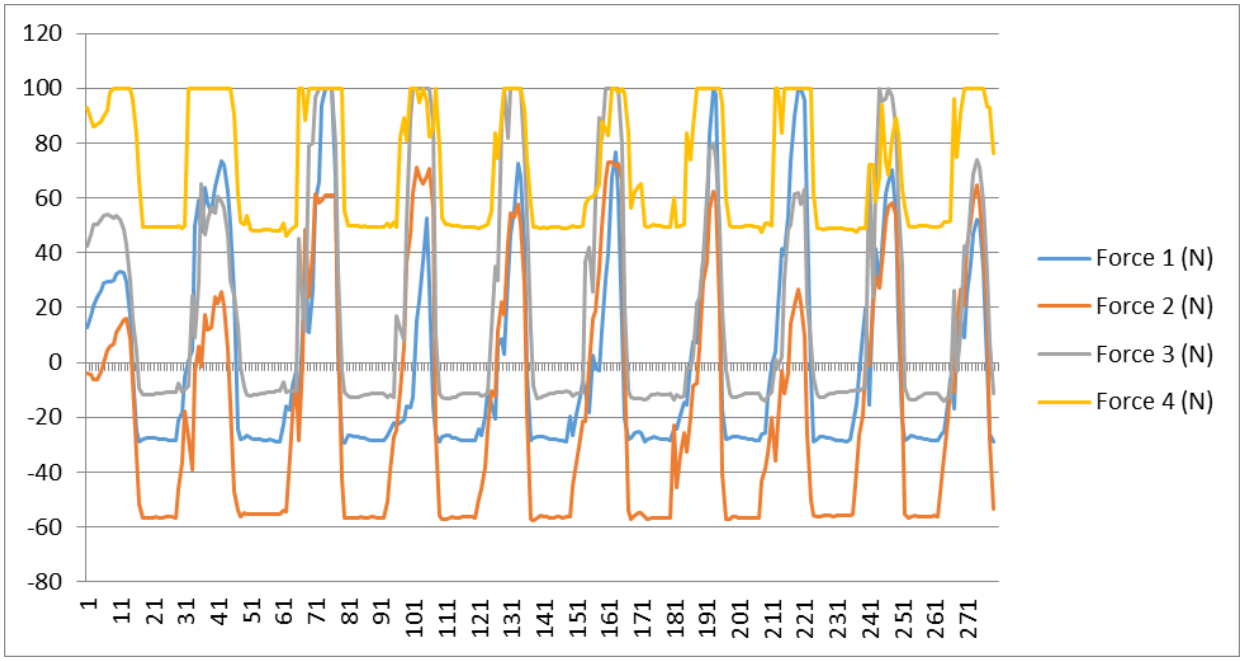

Figure 4.7.12(a): Graph of four forces of Subject XII

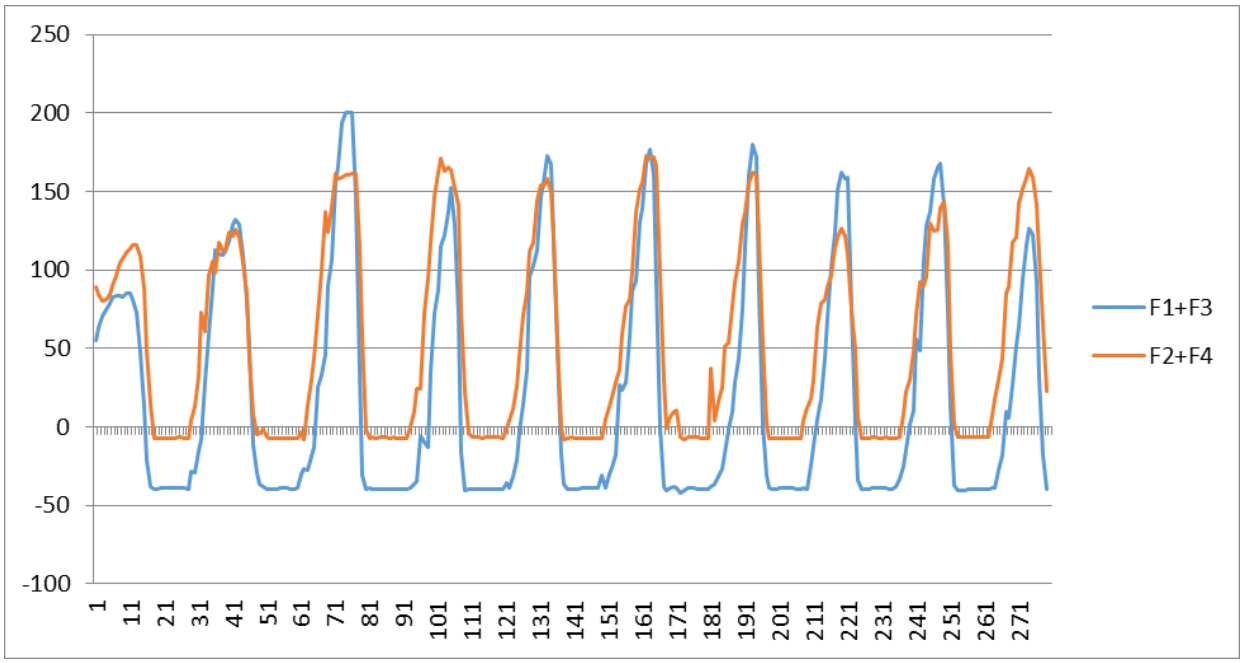

Figure 4.7.12(b): Graph of sum of two forces of Subject XII

Table 4.7.12: Data of Subject XII

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Step	Time (sec)	Right to left step length (in)	Left to right step length (in)	Stride Length (inch)	Condition
12	83	77	5”8	24.6	10	17	19.2	23.5	42.7	Normal Genomic

4.7.12 Analysis:

The rise and fall of forces in graph shows upper limb forces during handling of static walker used for gate by healthy genomic individual .At frist F1 rises upto 77N of force ,F2 rises to 23N of force similary F3 rises upto 62N and F4 upto 100N of force.The values of four forces changes diffrently from person to person because it depends on strenth of muscle,age,BMI of subject.The results are quite different form individuals with osteoporosis ,prosthetics and orthotics. Patient is taken as a subject to study walking pattern he is not an osteoporotic paptient. Hence proved that force is inversly propotional to velocity.

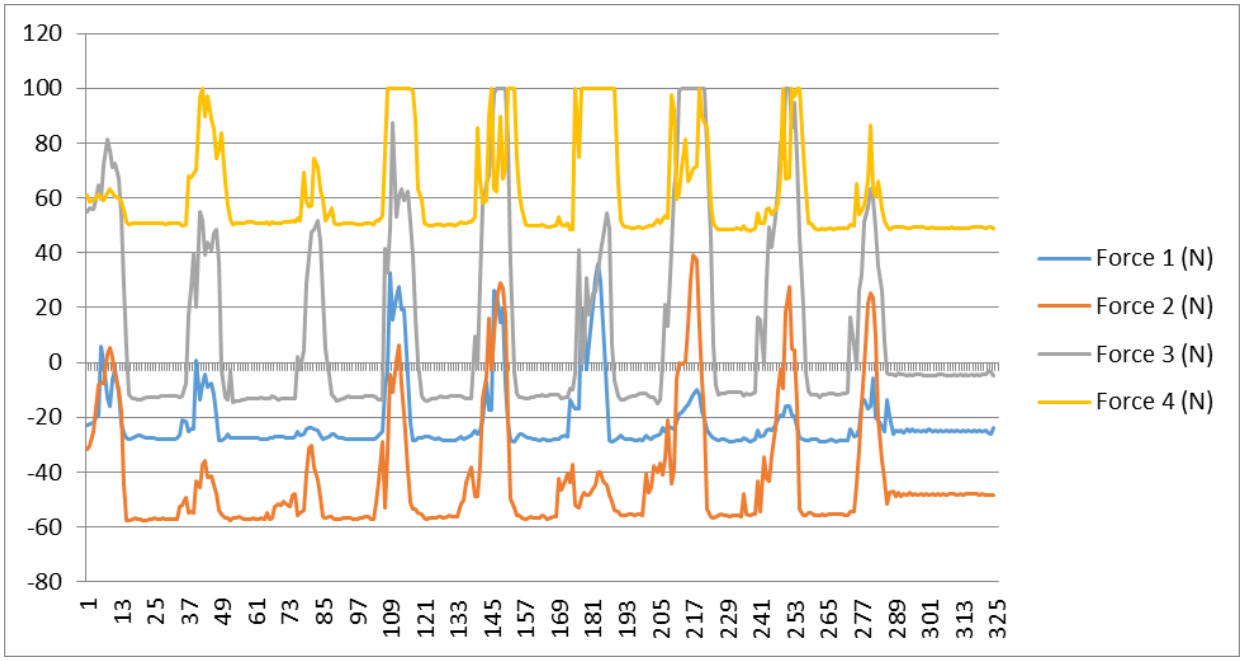

Figure 4.7.13(a): Graph of four forces of Subject XIII

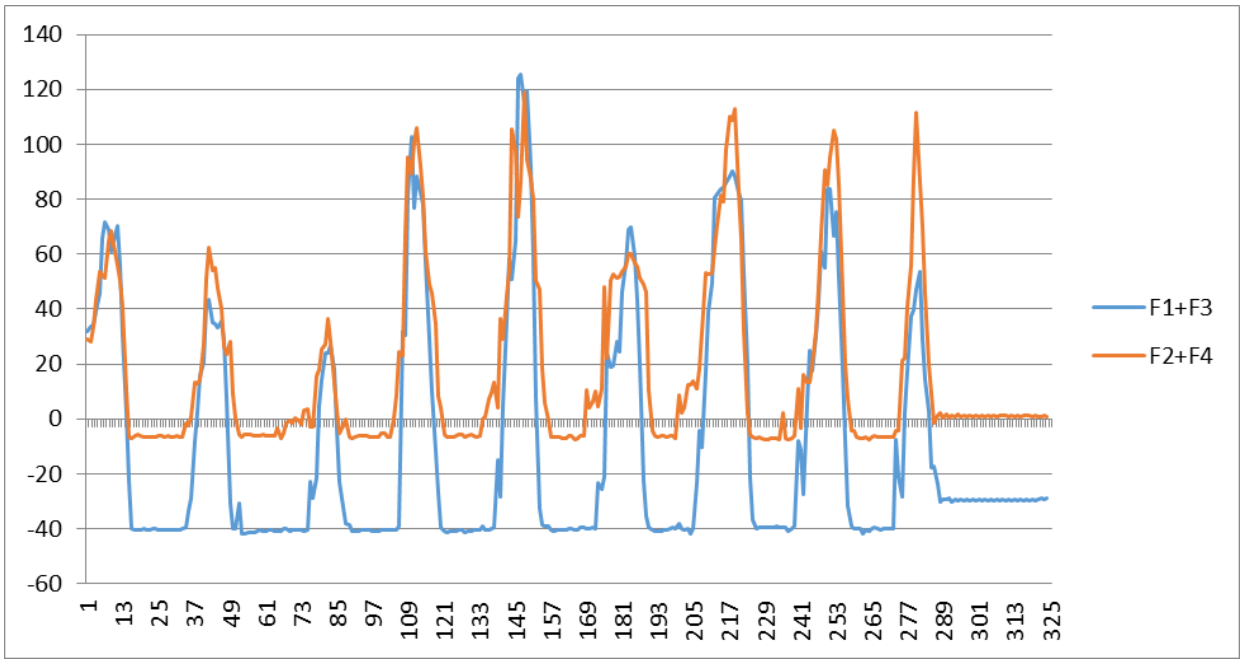

Figure 4.7.13(b): Graph of sum of two forces of Subject XIII

Table 4.7.13: Data of Subject XIII

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Step	Time (sec)	Right to left step length (in)	Left to right step length (in)	Stride Length (inch)	Condition
13	56	65	5”1	27.1	09	18	17	16.5	33.5	Normal Genomic

4.7.13 Analysis:

The rise and fall of forces in graph shows upper limb forces during handling of static walker used for gate by healthy genomic individual .At frist F1 rises upto 5N of force ,F2 rises to 5N of force similary F3 rises upto 61N and F4 upto 81N of force.The values of four forces changes diffrently from person to person because it depends on strenth of muscle,age,BMI of subject.The results are quite different form individuals with osteoporosis ,prosthetics and orthotics. Patient is taken as a subject to study walking pattern he is not an osteoporotic paptient. Hence proved that force is inversly propotional to velocity.

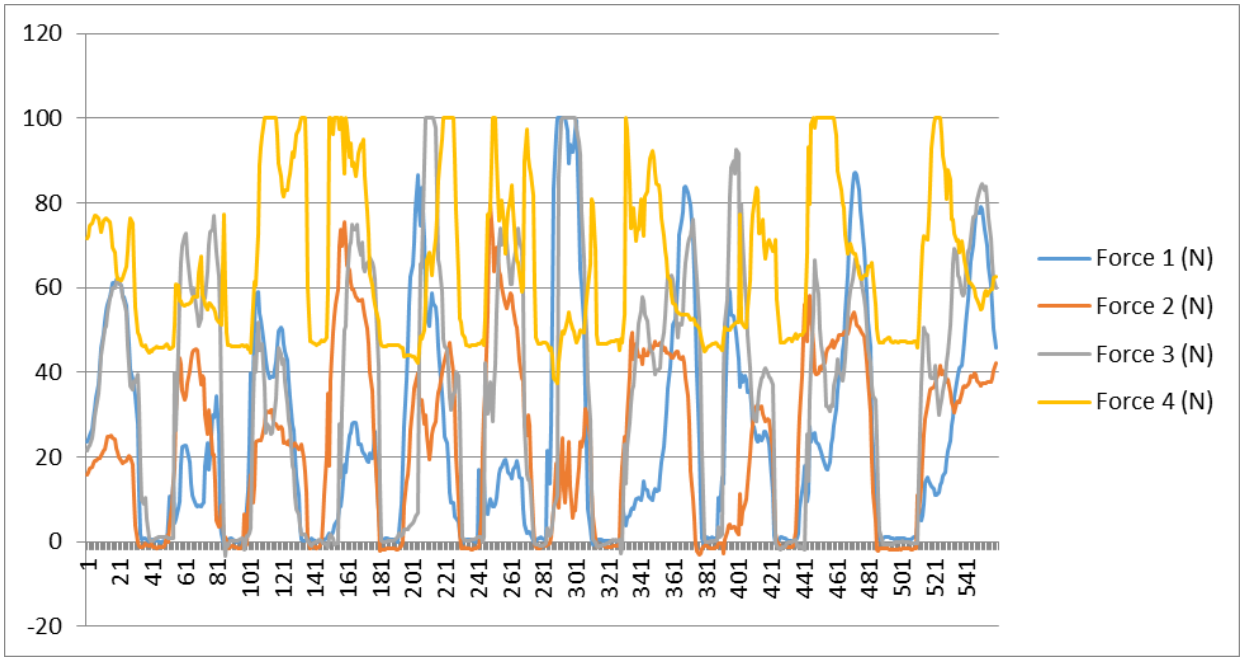

Figure 4.7.14(a): Graph of four forces of Subject XIV

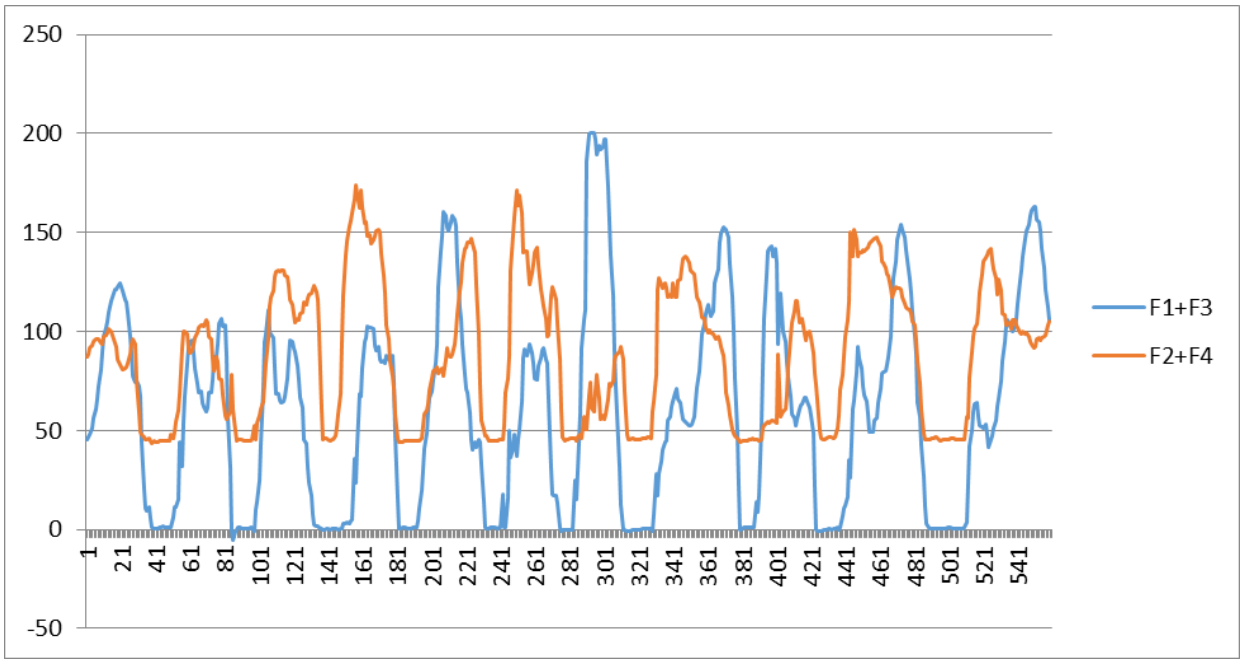

Figure 4.7.14(b): Graph of sum of two forces of Subject XIV

Table 4.7.14: Data of Subject XIV

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Step	Time (sec)	Right to left step length (in)	Left to right step length (in)	Stride Length (inch)	Condition
14	70	56	5”4	21.7	10	19	20	22	42	Normal Genomic

4.7.14 Analysis:

The rise and fall of forces in graph shows upper limb forces during handling of static walker used for gate by healthy genomic individual .At frist F1 rises upto 60N of force ,F2 rises to 23N of force similary F3 rises upto 61N and F4 upto 78N of force.The values of four forces changes diffrently from person to person because it depends on strenth of muscle,age,BMI of subject.The results are quite different form individuals with osteoporosis ,prosthetics and orthotics. Patient is taken as a subject to study walking pattern he is not an osteoporotic paptient. Hence proved that force is inversly propotional to velocity.

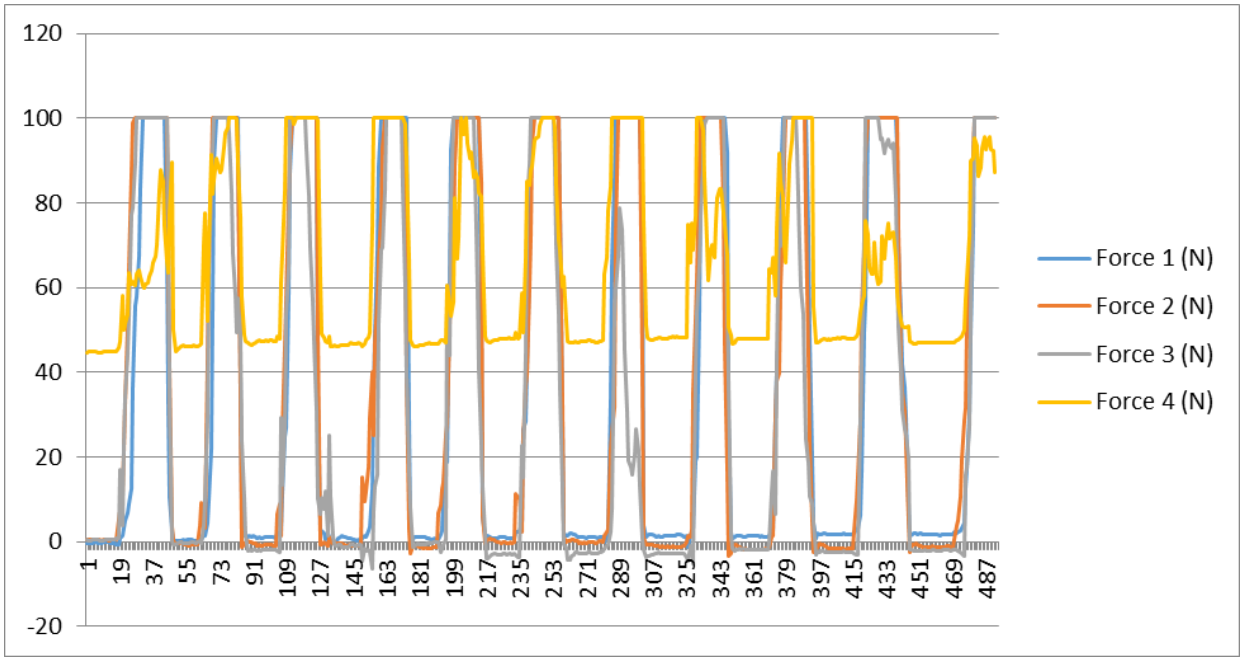

Figure 4.7.15(a): Graph of four forces of Subject XV

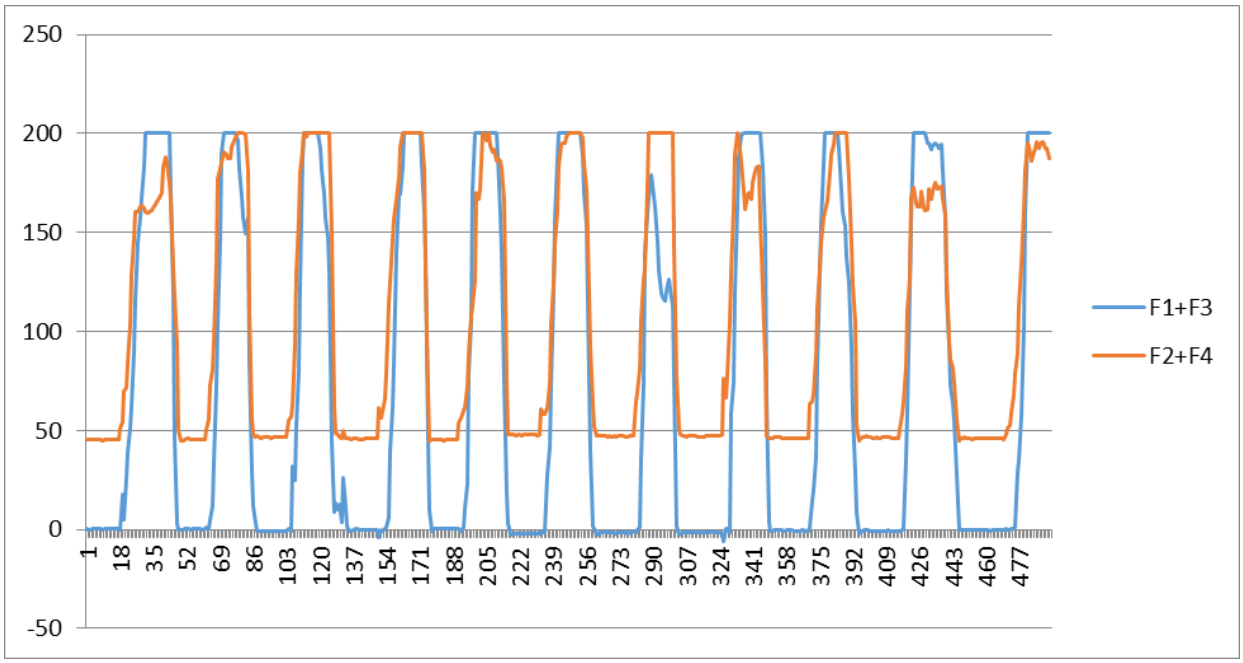

Figure 4.7.15(b): Graph of sum of two forces of Subject XV

Table 4.7.15: Data of Subject XV

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Step	Time (sec)	Right to left step length (in)	Left to right step length (in)	Stride Length (inch)	Condition
15	67	65	5”5	23.9	10	18	16.5	18	34.5	Normal Genomic

4.7.15 Analysis:

The rise and fall of forces in graph shows upper limb forces during handling of static walker used for gate by healthy genomic individual .At frist F1 rises upto 100N of force ,F2 rises to 100N of force similary F3 rises upto 100N and F4 upto 90N of force.The values of four forces changes diffrently from person to person because it depends on strenth of muscle,age,BMI of subject.The results are quite different form individuals with osteoporosis ,prosthetics and orthotics. Patient is taken as a subject to study walking pattern he is not an osteoporotic paptient. Hence proved that force is inversly propotional to velocity.

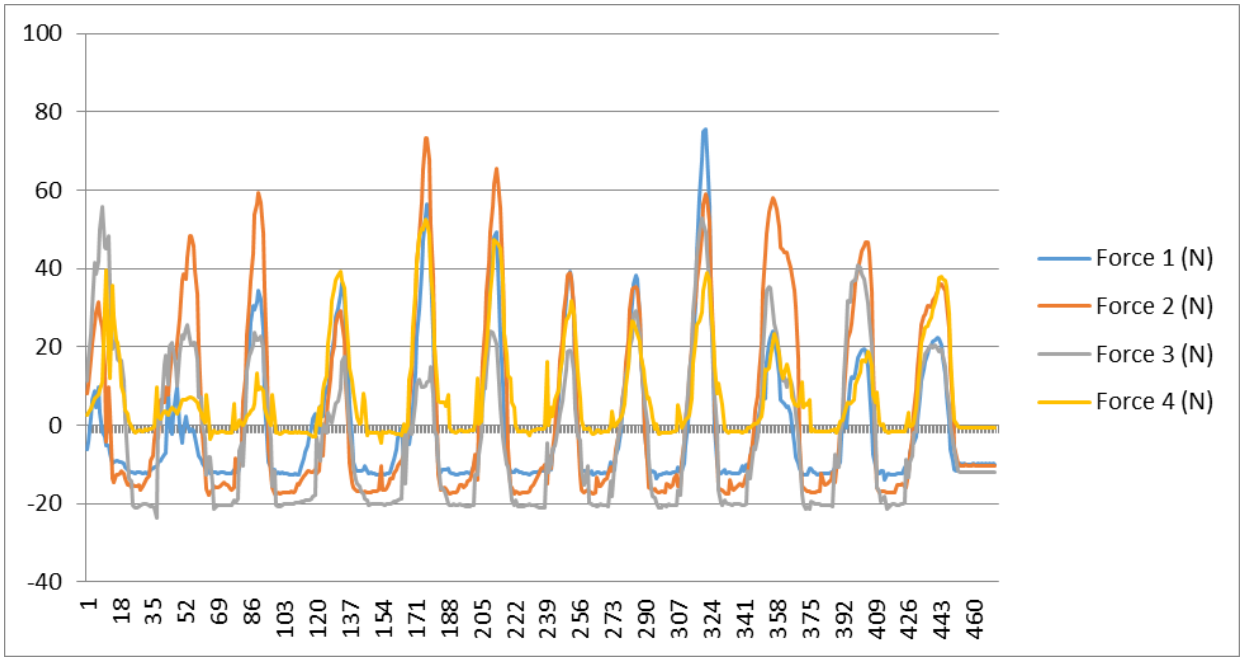

Figure 4.7.16(a): Graph of four forces of Subject XVI

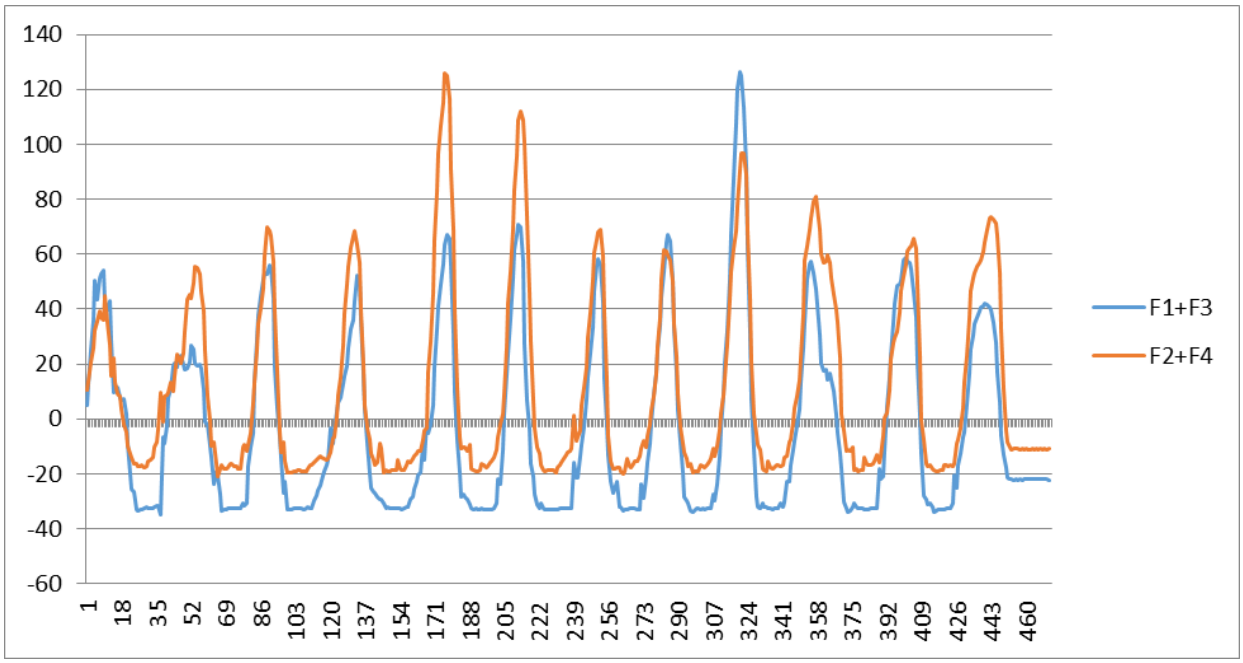

Figure 4.7.16(b): Graph of sum of two forces of Subject XVI

Table 4.7.16: Data of Subject XVI

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Step	Time (sec)	Right to left step length (in)	Left to right step length (in)	Stride Length (inch)	Condition
16	62	69	5”4	26	10	17	18.2	16	34.2	Normal Genomic

4.7.16 Analysis:

The rise and fall of forces in graph shows upper limb forces during handling of static walker used for gate by healthy genomic individual .At frist F1 rises upto 10N of force ,F2 rises to 33N of force similary F3 rises upto 58N and F4 upto 40N of force.The values of four forces changes diffrently from person to person because it depends on strenth of muscle,age,BMI of subject.The results are quite different form individuals with osteoporosis ,prosthetics and orthotics. Patient is taken as a subject to study walking pattern he is not an osteoporotic paptient. Hence proved that force is inversly propotional to velocity.

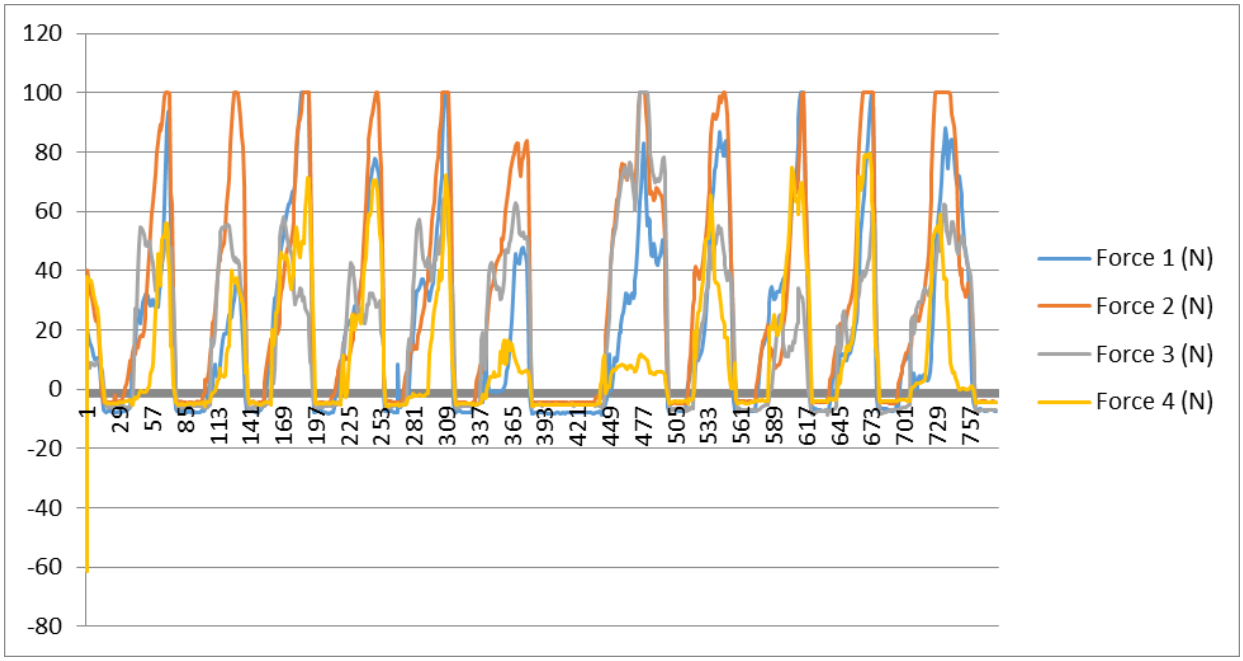

Figure 4.7.17(a): Graph of four forces of Subject XVII

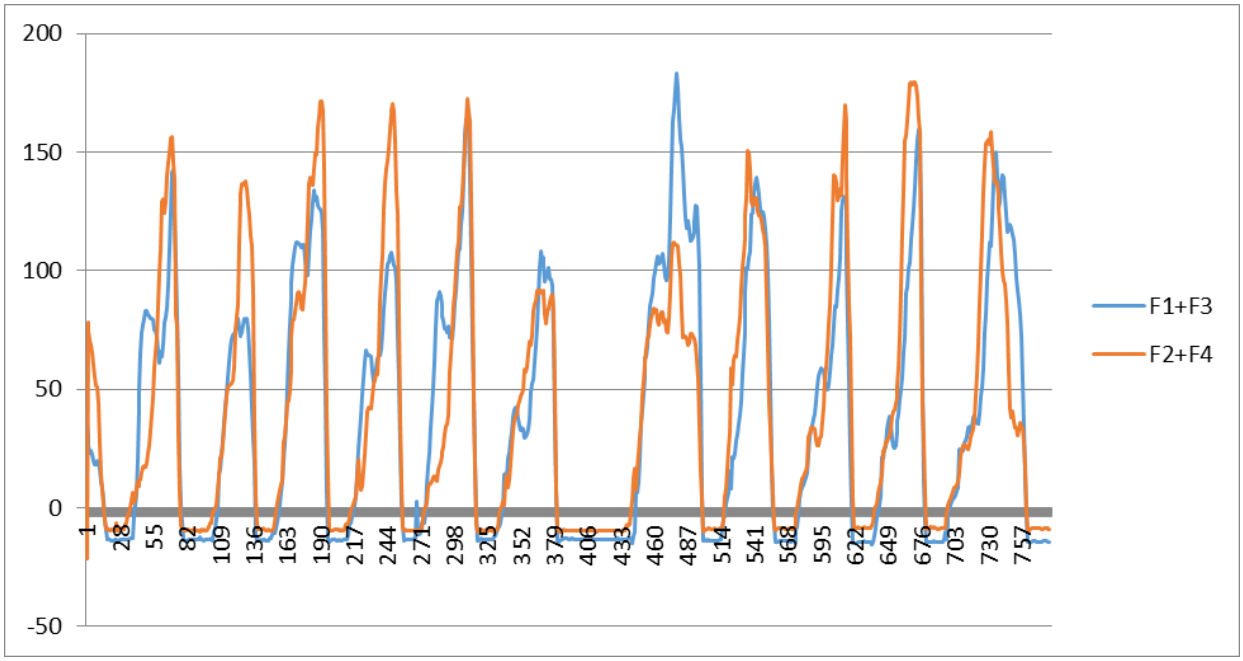

Figure 4.7.17(b): Graph of sum of two forces of Subject XVII

Table 4.7.17: Data of Subject XVII

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Step	Time (sec)	Right to left step length (in)	Left to right step length (in)	Stride Length (inch)	Condition
17	60	62	5”2	25.2	10	18	21.5	13.5	35	Normal Genomic

4.7.17 Analysis:

The rise and fall of forces in graph shows upper limb forces during handling of static walker used for gate by healthy genomic individual. At first F1 rises upto 100N of force, F2 rises to 100N of force similary F3 rises upto 58N and F4 upto 59N of force.The values of four forces changes diffrently from person to person because it depends on strenth of muscle, age, BMI of subject.The results are quite different form individuals with osteoporosis, prosthetics and orthotics. Patient is taken as a subject to study walking pattern she is not an osteoporotic paptient. Hence, it is proved that force is inversly propotional to velocity.

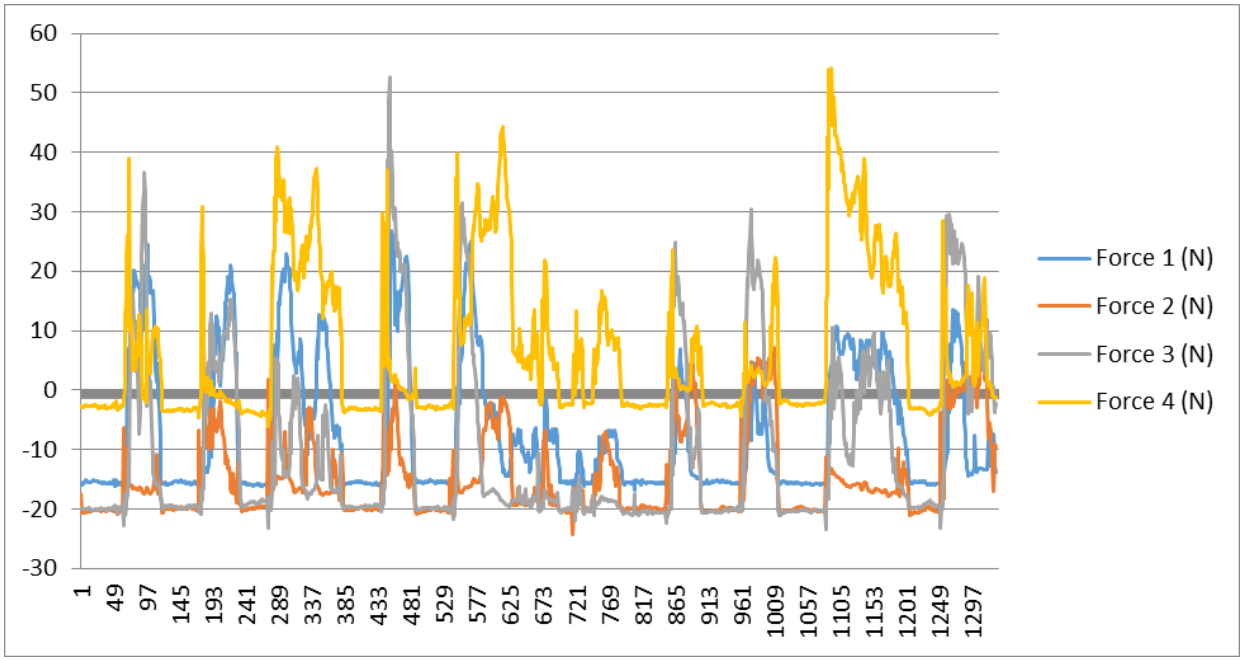

Figure 4.7.18(a): Graph of four forces of Subject XVIII

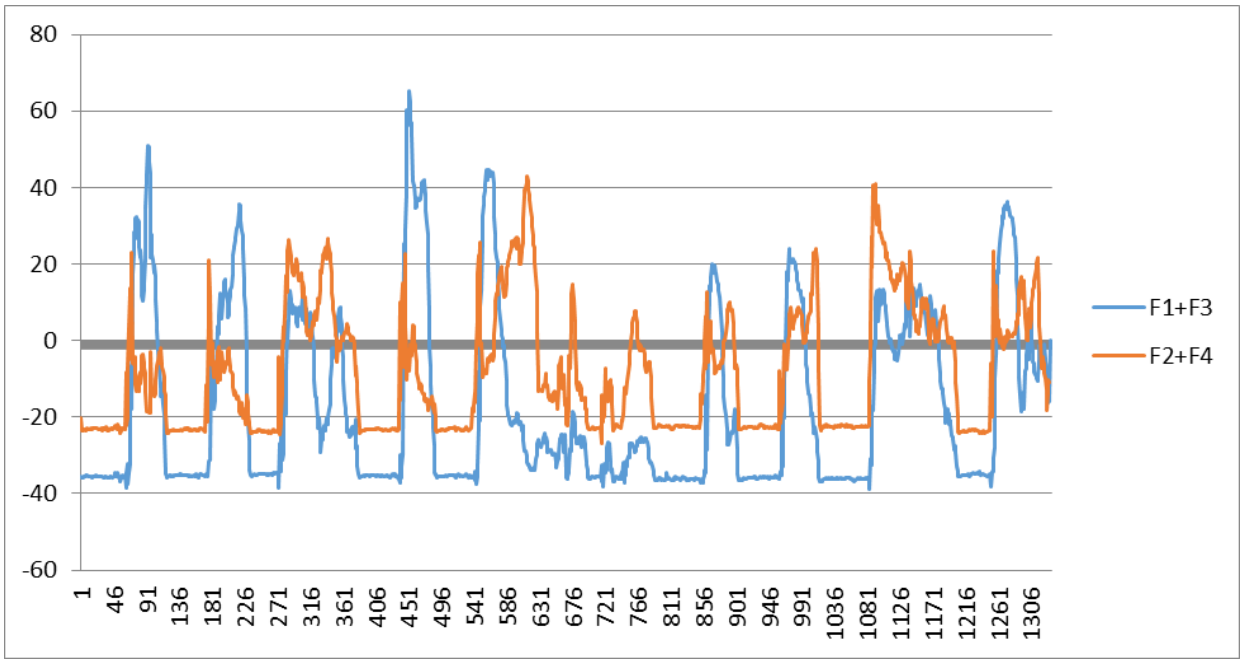

Figure 4.7.18(b): Graph of sum of two forces of Subject XVIII

Table 4.7.18: Data of Subject XVIII

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Step	Time (sec)	Right to left step length (in)	Left to right step length (in)	Stride Length (inch)	Condition
18	71	67	5”6	23.7	10	19	19	17.2	36.2	Normal Genomic

4.7.18 Analysis:

The rise and fall of forces in graph shows upper limb forces during handling of static walker used for gate by healthy genomic individual. At first F1 rises up to 25N of force, F2 rises to -4N of force similarly F3 rises up to 38N and F4 up to 39N of force. The values of four forces changes differently from person to person because it depends on strength of muscle, age, BMI of subject. The results are quite different form individuals with osteoporosis, prosthetics and orthotics. Patient is taken as a subject to study walking pattern she is not an osteoporotic patient. Hence, it is proved that force is inversely proportional to velocity.

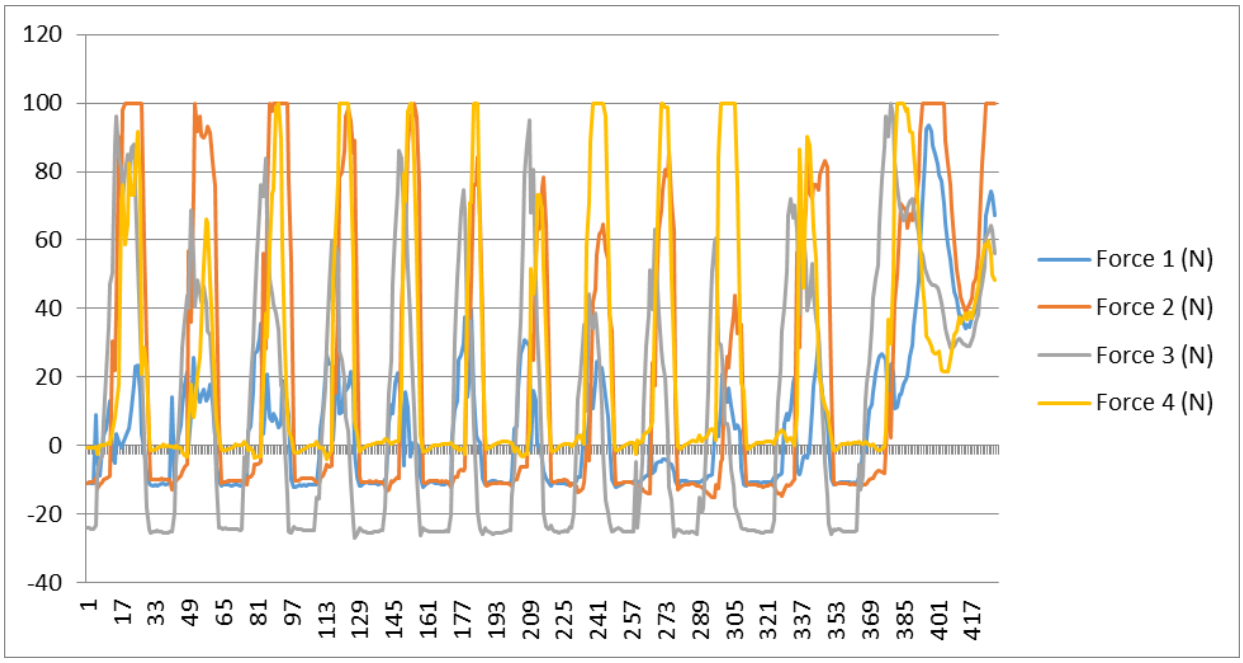

Figure 4.7.19(a): Graph of four forces of Subject XIX

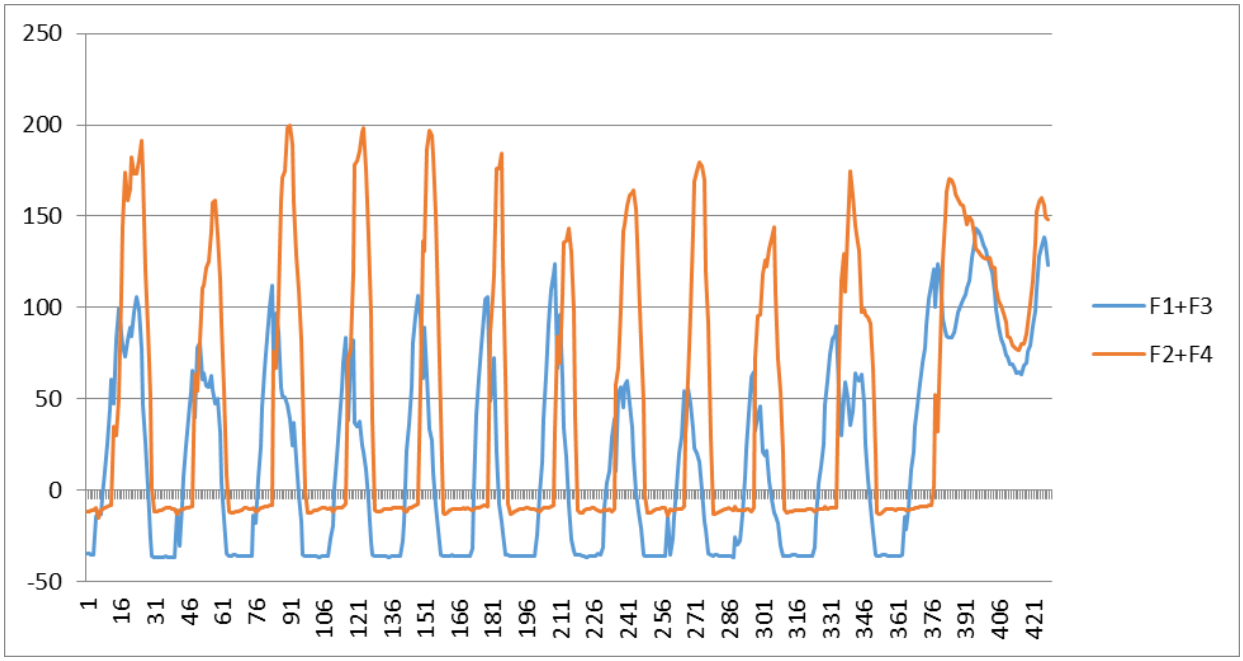

Figure 4.7.19(b): Graph of sum of two forces of Subject XIX

Table 4.7.19: Data of Subject XIX

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Step	Time (sec)	Right to left step length (in)	Left to right step length (in)	Stride Length (inch)	Condition
19	80	59	5”7	20.4	10	21	18	22	40	Normal Genomic

4.7.19 Analysis:

The rise and fall of forces in graph shows upper limb forces during handling of static walker used for gate by healthy genomic individual. At first F1 rises up to 22N of force, F2 rises to 100N of force similarly F3 rises up to 98N and F4 up to 95N of force. The values of four forces changes differently from person to person because it depends on strength of muscle, age, BMI of subject. The results are quite different form individuals with osteoporosis, prosthetics and orthotics. Patient is taken as a subject to study walking pattern he is not an osteoporotic patient. Hence, it is proved that force is inversely proportional to velocity.

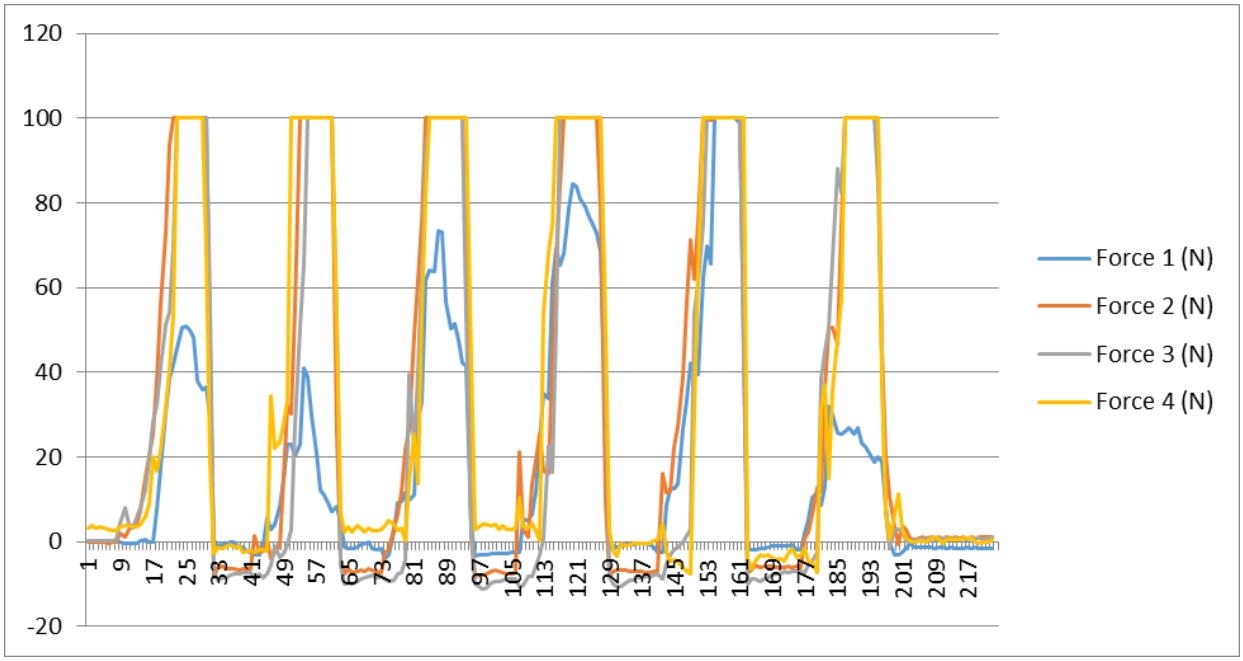

Figure 4.7.20(a): Graph of four forces of Subject XX

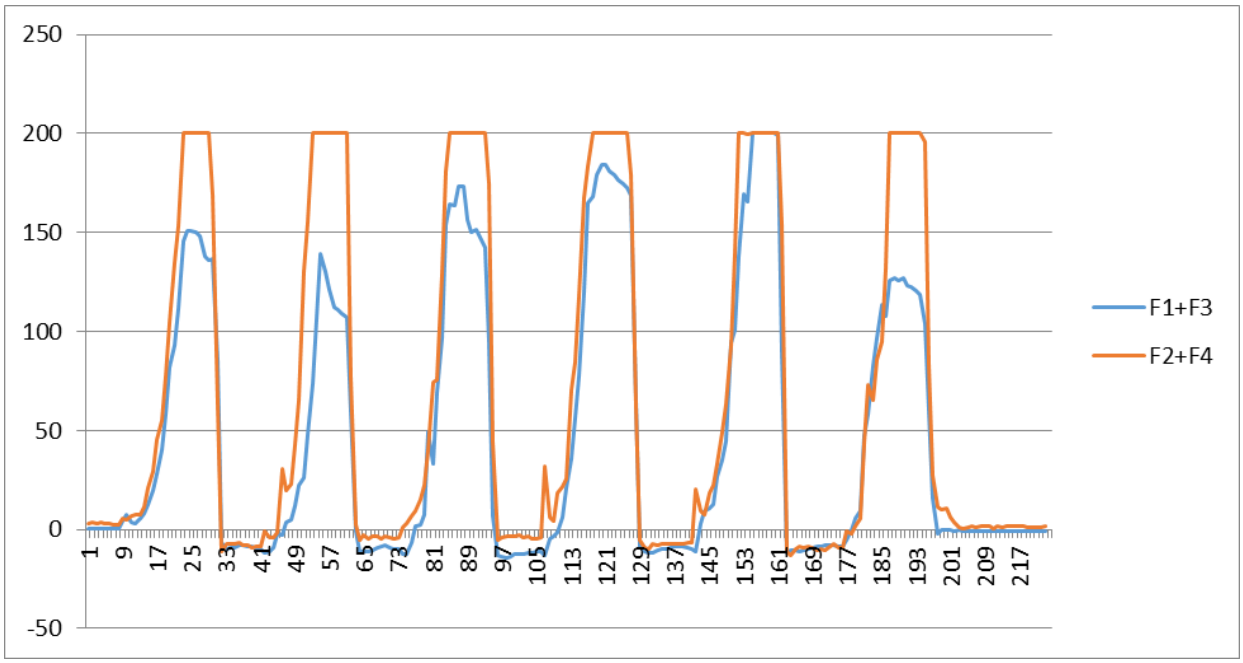

Figure 4.7.20(b): Graph of sum of two forces of Subject XX

Table 4.7.20: Data of Subject XX

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Step	Time (sec)	Right to left step length (in)	Left to right step length (in)	Stride Length (inch)	Condition
20	60	64	5”10	20.2	06	16	22	23.5	45	Normal Genomic

4.7.20 Analysis:

The rise and fall of forces in graph shows upper limb forces during handling of static walker used for gate by healthy genomic individual .At frist F1 rises upto 50N of force ,F2 rises to 100N of force similary F3 rises upto 100N and F4 upto 100N of force.The values of four forces changes diffrently from person to person because it depends on strenth of muscle,age,BMI of subject.The results are quite different form individuals with osteoporosis ,prosthetics and orthotics. Patient is taken as a subject to study walking pattern she is not an osteoporotic paptient. Hence proved that force is inversly propotional to velocity.

4.8 Data Graphs and Analysis of Diseased Subjects:

The 20 figures with two parts (a) and (b) contain the graphs of diseased subjects in which the first part is the graphical representation of the four forces applied on each leg of the walking frame while the second part is the graphical representation of sum of two forces applied on each side of the walking frame. The peaks are abnormal and very much unlike in the case of patients.

The analysis of data of all diseased subjects is performed individually which is mentioned with details along with the table of data collected of each subject.

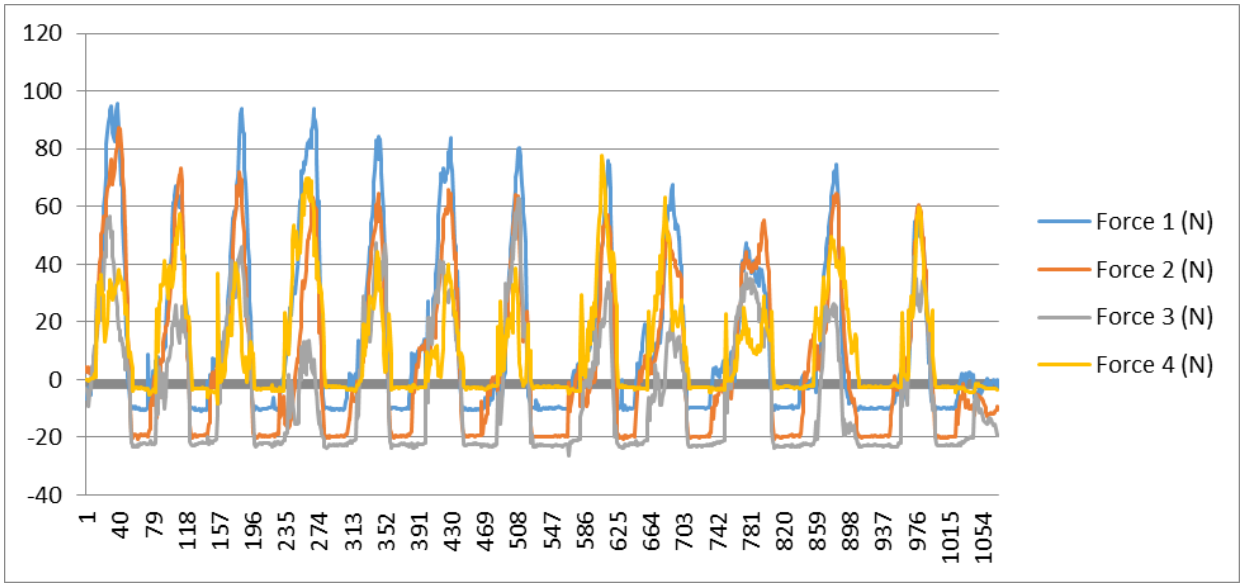

Figure 4.8.1(a): Graph of four forces of Diseased Subject I [Problem in F2 and F3 i.e. both legs due to arthritis]

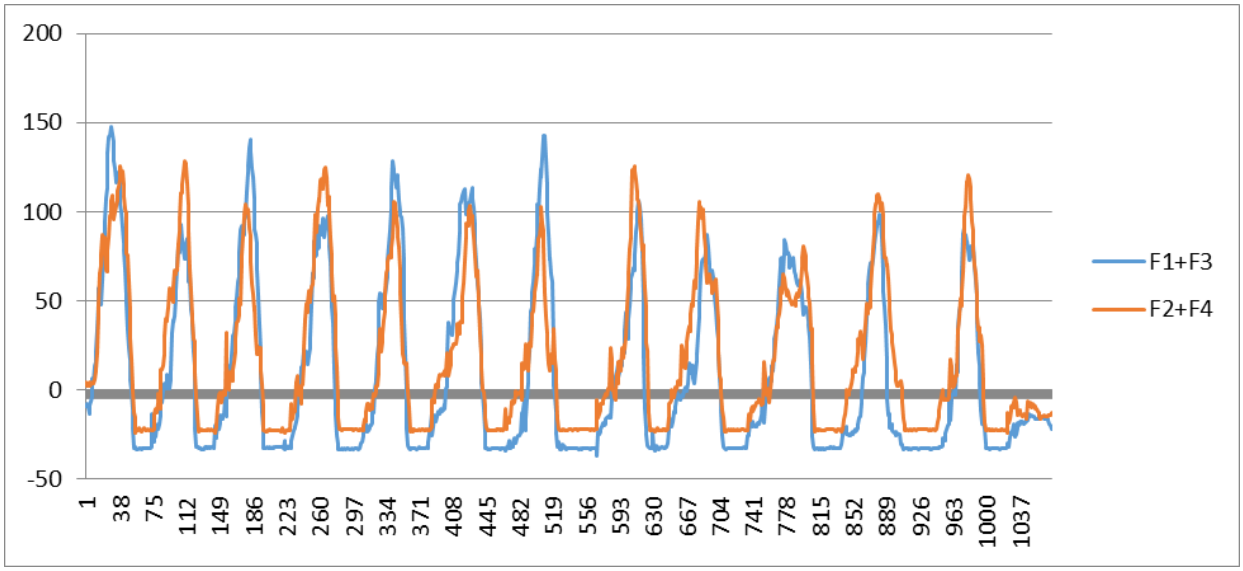

Figure 4.8.1(b): Graph of sum of two forces of Diseased Subject I

Table 4.8.1: Data of Diseased Subject I

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Steps	Time (sec)	Right to Left Step Length (in)	Left to Right Step Length (in)	Stride Length (inch)	Condition
1	56	48	5’’3	21.5	07	22	1	14.	28.5	osteoporosis

4.8.1 Analysis:

At the first step the value of F1 increase to the point of around 90N, F2 increase to the 80N, F3 increases to the 50N and F4 to the 25N. When the patient walks and apply force the peaks touches its maximum heights and when it releases its force than the peaks decreases. Due to the disease condition of osteoporosis the gait pattern will change at every point also that the sum forces of F1 and F3 will show that Left Leg is more affected as compare to the sum forces of F2 and F4 i.e Right leg. Patient requires more upper limb force to move forward because due to increase in force the velocity decreases. Also that as the age increases the muscle force also increase due to which the velocity decrease as the time increases.

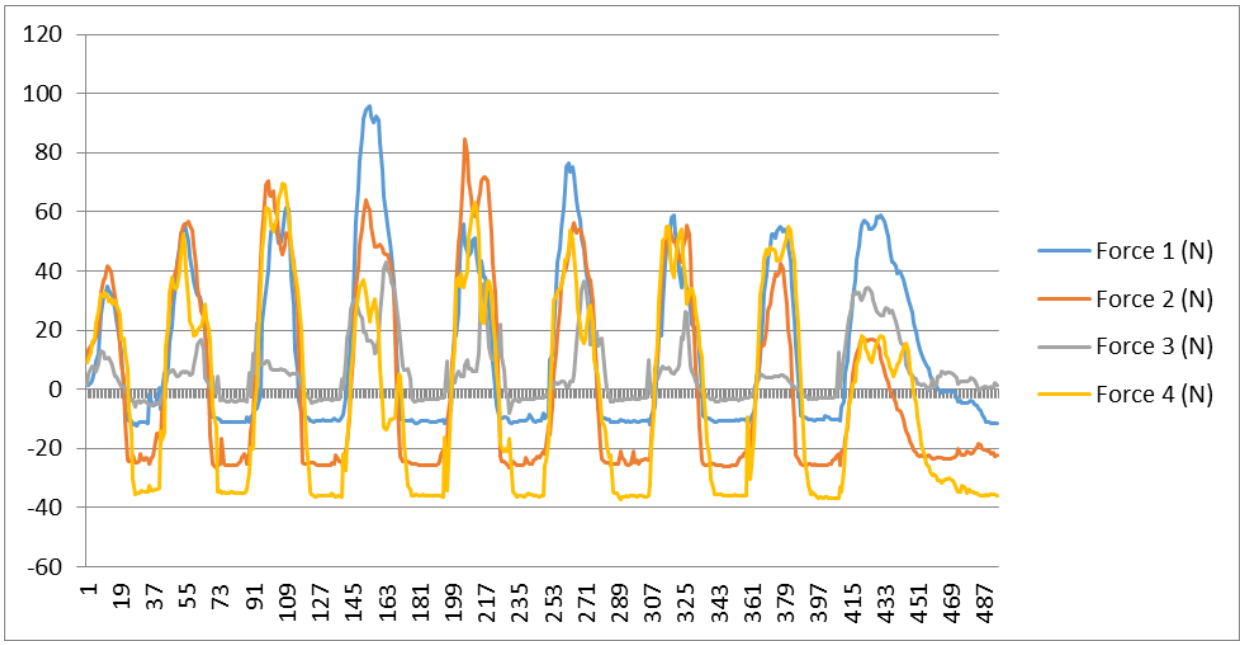

Figure 4.8.2(a): Graph of four forces of Diseased Subject II [Problem in F2 and F4 which is right leg and less force applied due to less weight]

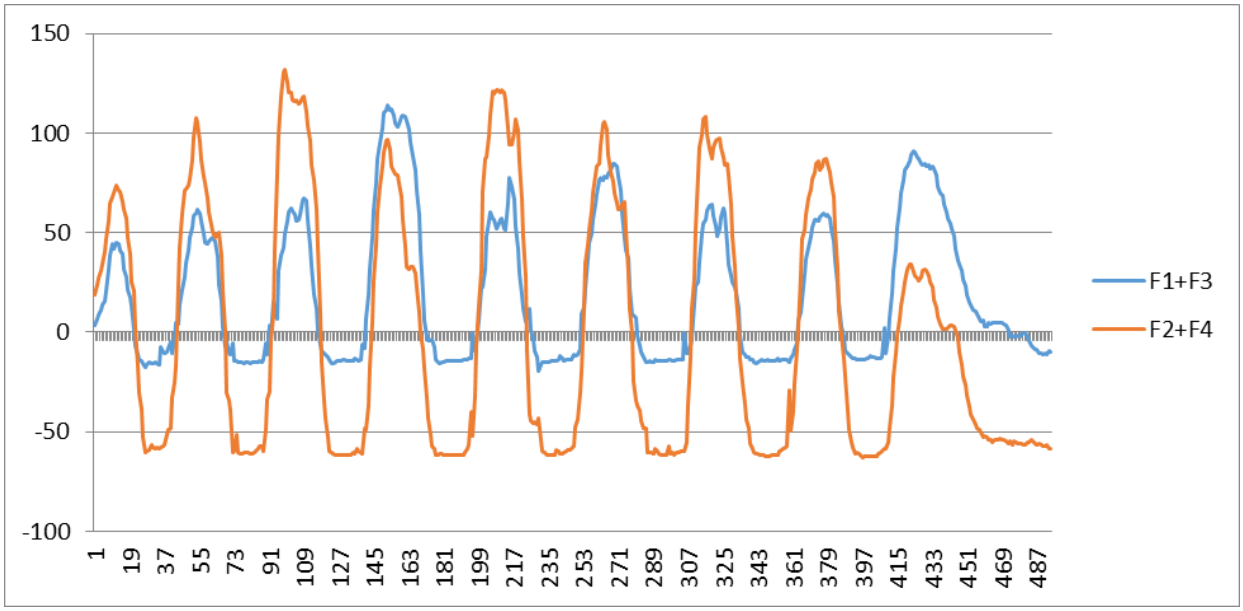

Figure 4.8.2(b): Graph of sum of two forces of Diseased Subject II

Table 4.8.2: Data of Diseased Subject II

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Steps	Time (sec)	Right to Left Step Length (in)	Left to Right Step Length (in)	Stride Length (inch)	Condition
2	36	50	5’’3	19.5	08	21	18	21	39	osteoporosis

4.8.2 Analysis:

The value of F1 increase from 0N to 35N, F2 increase up to 40N, F3 will gain the 10N and F4 will be the 29N. When the patient walks and apply force the peaks touches its maximum heights and when it releases its force than the peaks decreases. So the sum forces of F1+F3 is approximately 130N which is are greater as compare to the sum forces of F2+F4 is below 70N. Due to low value force of right leg indicates that patient is osteoporosis. Due to the disease of osteoporosis the velocity of the patient also decrease which is shown in the steps of patient. Patient require more upper limb force to move forward because due to increase in force the velocity decrease. Also that as the age increases the muscle force also increase due to which the velocity decrease ad the time increases.

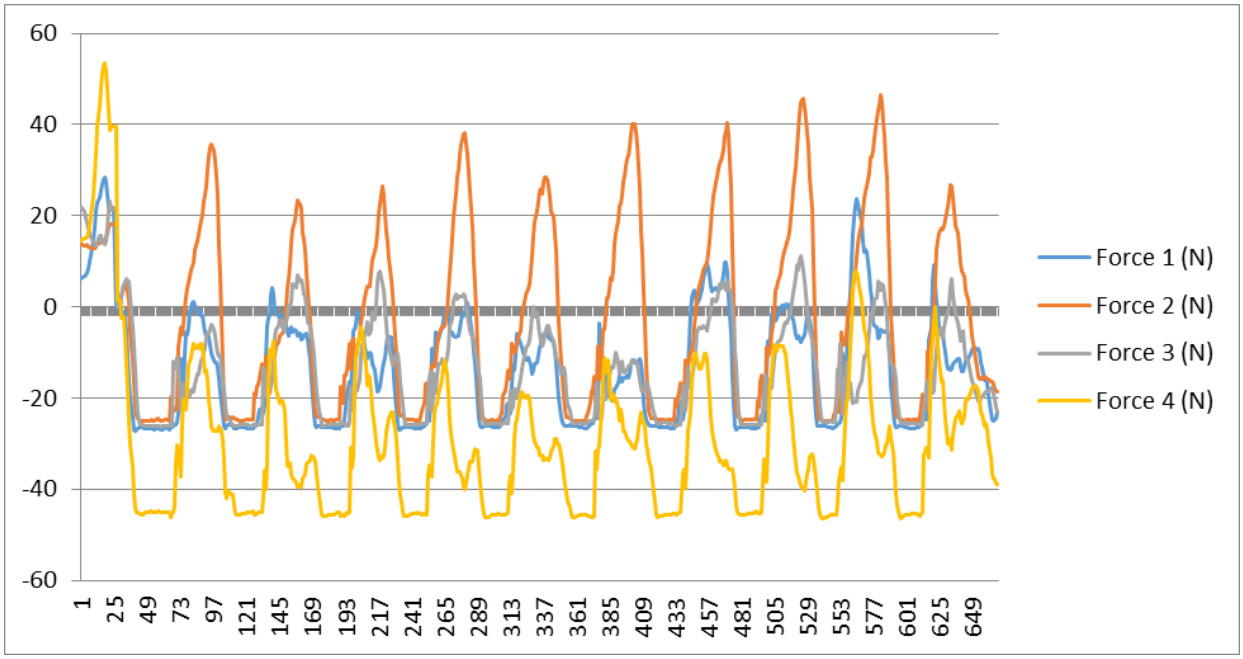

Figure 4.8.3(a): Graph of four forces of Diseased Subject III [Problem in left leg i.e. F1 and F3 due to joints problem]

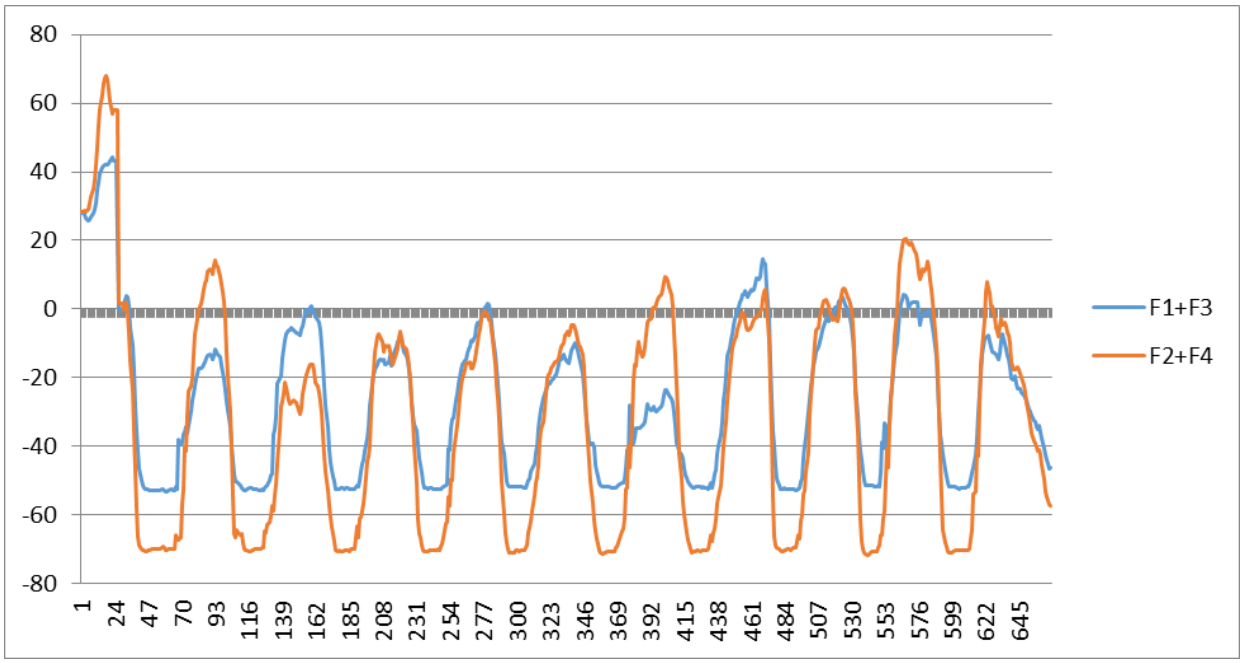

Figure 4.8.3(b): Graph of sum of two forces of Diseased Subject III

Table 4.8.1: Data of Diseased Subject III

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Steps	Time (sec)	Right to Left Step Length (in)	Left to Right Step Length (in)	Stride Length (inch)	Condition
3	52	62	5’’4	23.3	07	23	18.2	21.5	39.7	osteoporosis

4.8.3 Analysis:

The F1 force increase up to 30N, F2 increase to 15N, F3 up to 22N and F4 55N.After the increase in the force the graph shows the sudden change of gait pattern and all the forces decrease from the normal range except the force of F2. The decrease in forces shows that there is problem in both the legs of patient. The decrease in forces show that F1 is 0N, F3 is -5N and F4 will decrease up to -10N. The condition of Left leg is more severe due to low balancing of forces as compare to the right leg. Patient required more upper limb force to move forward because due to increase in force the velocity decreased. Also that as the age increases the muscle force also increase due to which the velocity decrease ad the time increases.

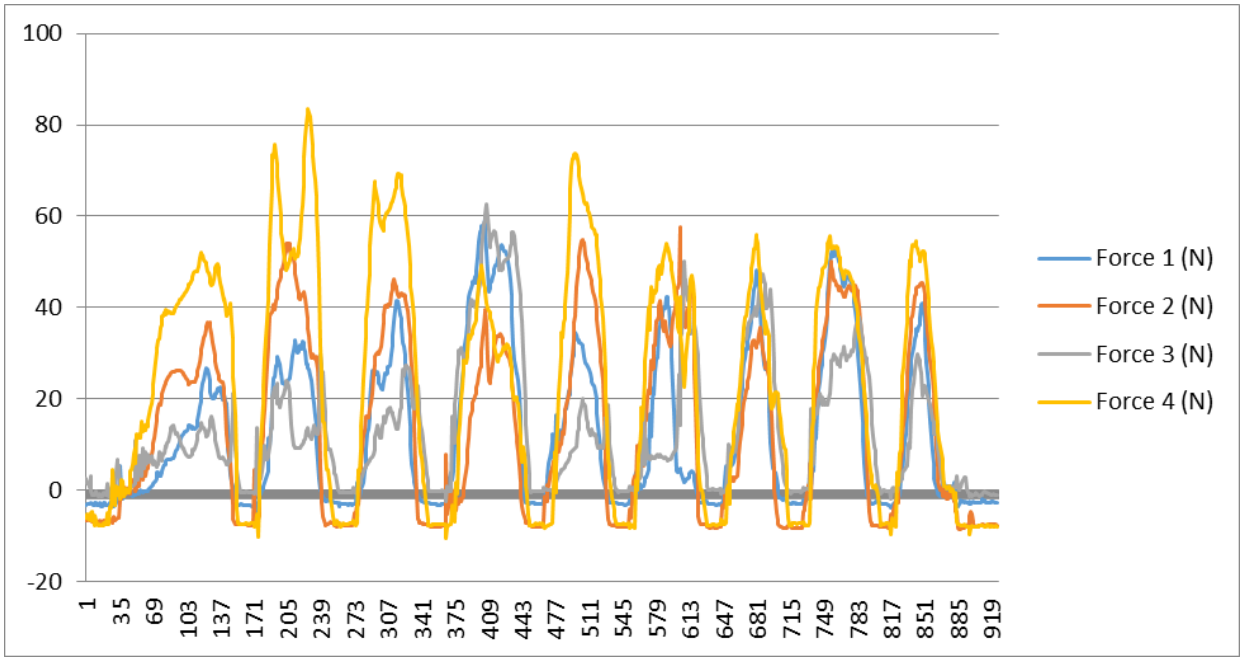

Figure 4.8.4(a): Graph of four forces of Diseased Subject IV [Slightly problem in right leg due to decrease force in F4]

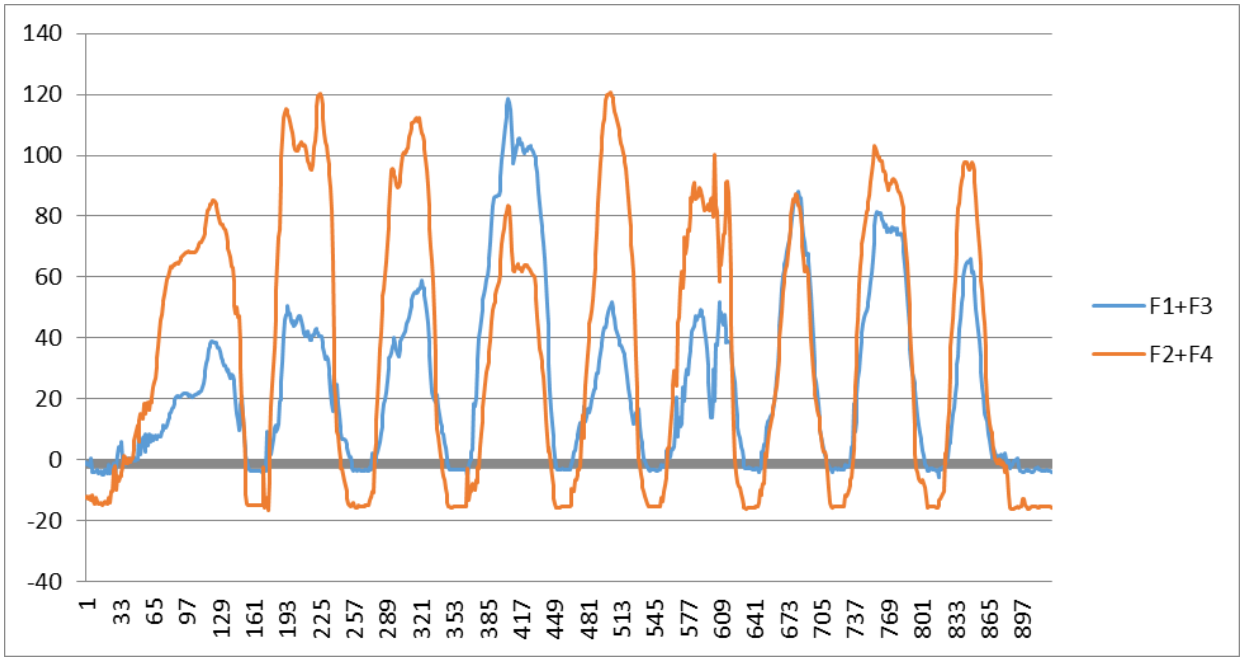

Figure 4.8.4(b): Graph of sum of two forces of Diseased Subject IV

Table 4.8.4: Data of Diseased Subject IV

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Steps	Time (sec)	Right to Left Step Length (in)	Left to Right Step Length (in)	Stride Length (inch)	Condition
4	36	52	5’’25	21.1	07	24	19	22.2	41.2	osteoporosis

4.8.4 Analysis:

The increase of forces is analysis in the beginning i.e the F1 reaches up to 25N, F2 35N, F3 18N and F4 45N. The graph shows the unpredictable readings in the forces of F1 and F3, due to these unmatched and non periodic readings. We analysis that patient suffers abnormal gait pattern due to the Left leg walking pattern. Furthermore, from above table we can see that the steps are less as compare the patient need more time to walk, which proves the equation i.e the upper limb forces are inversely proportional to the velocity of the body. Patient require more upper limb force to move forward because due to increase in force the velocity decrease. Also that as the age increases the muscle force also increase due to which the velocity decrease ad the time increases.

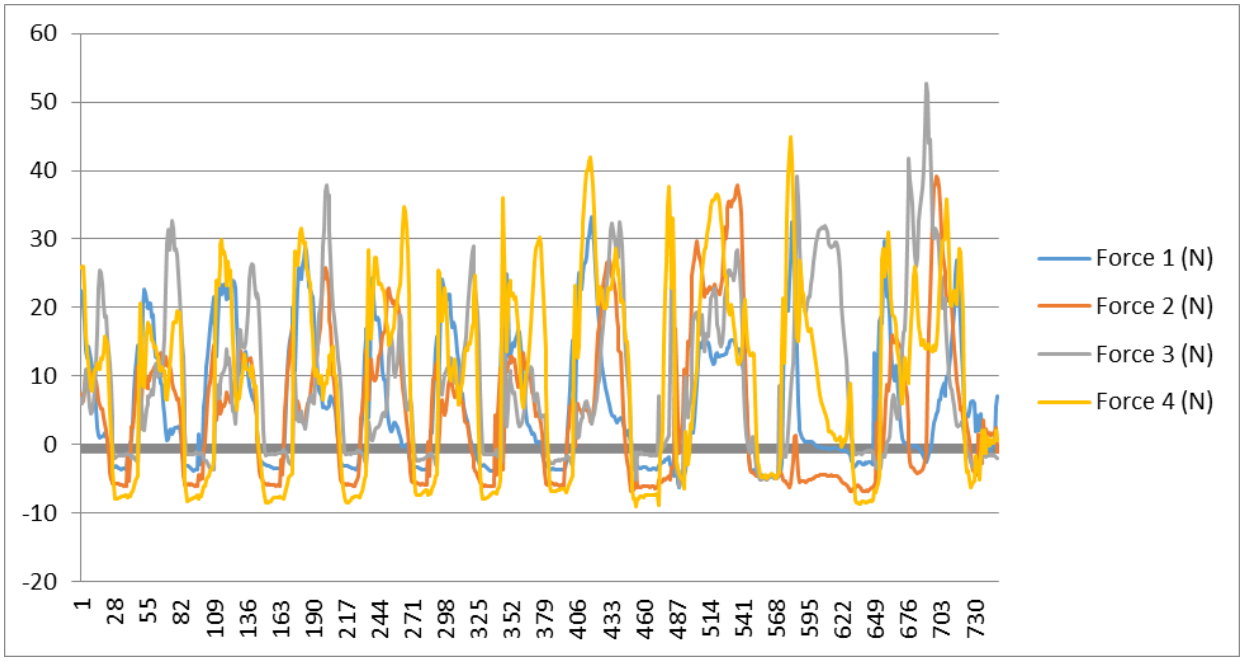

Figure 4.8.5(a): Graph of four forces of Diseased Subject V [Problem in F1 and F3 means problem in Left leg and problem walking with stability due to orthosis implantation surgery]

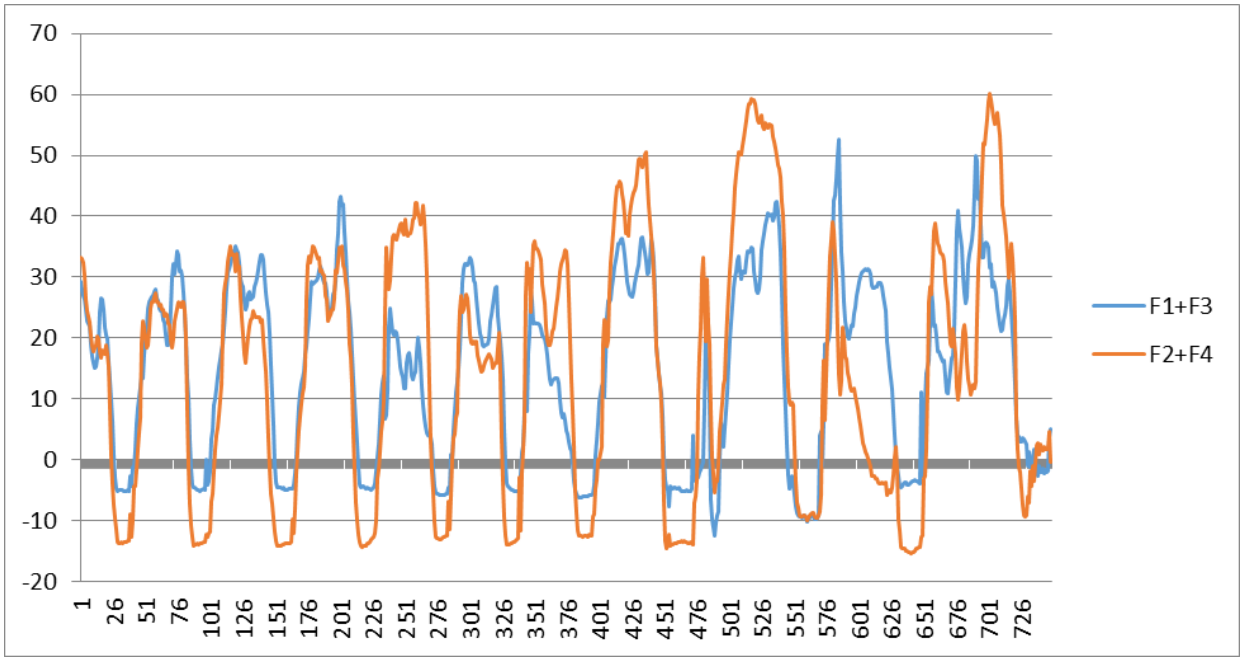

Figure 4.8.5(b): Graph of sum of two forces of Diseased Subject V

Table 4.8.5: Data of Diseased Subject V

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Steps	Time (sec)	Right to Left Step Length (in)	Left to Right Step Length (in)	Stride Length (inch)	Condition
5	72	57	5’’2	23.1	05	28	17	19	36	osteoporosis

4.8.5 Analysis:

The graph shows the upwards and down wards movements of forces. Initially the F1 force touches the value of 21N, F2 10N, F3 25N and F4 25N. The values of four forces vary very differently and the sum of both sides F1+F3 and F2+F4 are not matching the comparative values of healthy genomic patient’s graph values. It has been proved that, Patient require more upper limb force to move forward because due to increase in force the velocity decrease. Also that as the age increases the muscle force also increase due to which the velocity decrease ad the time increases. Due to the variations of forces in F1 and F3 we can predict that the condition of Left leg is more severe as compare to the right leg.

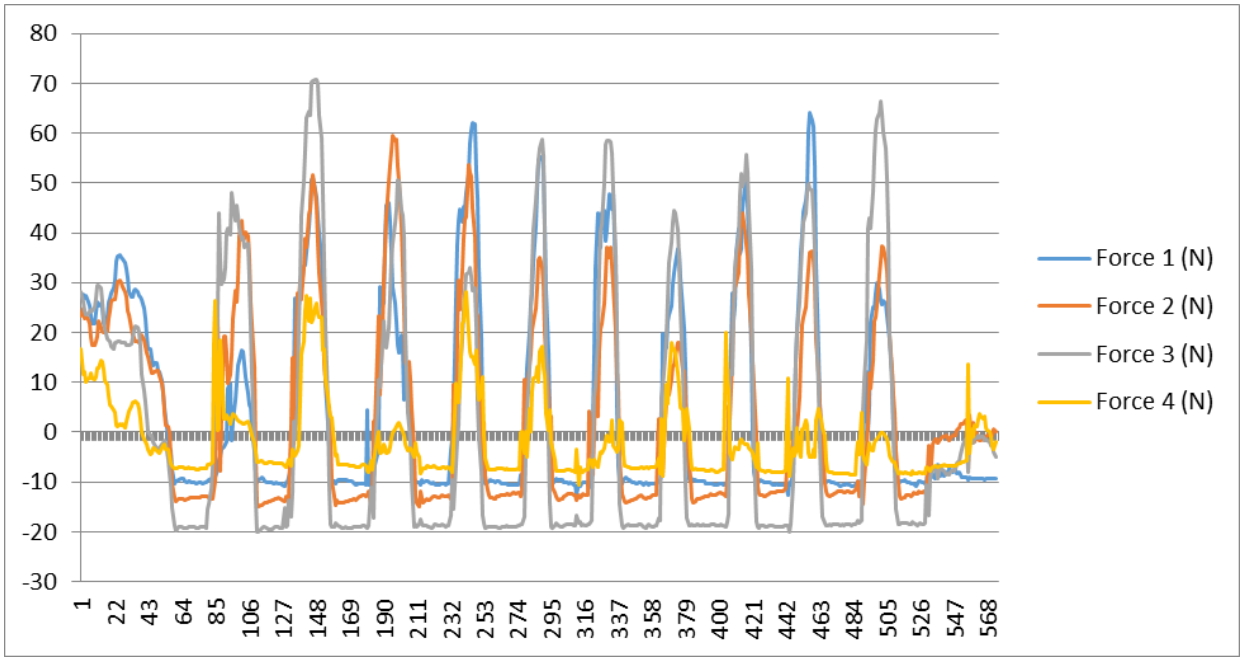

Figure 4.8.6(a): Graph of four forces of Diseased Subject VI [Problem in both the Legs]

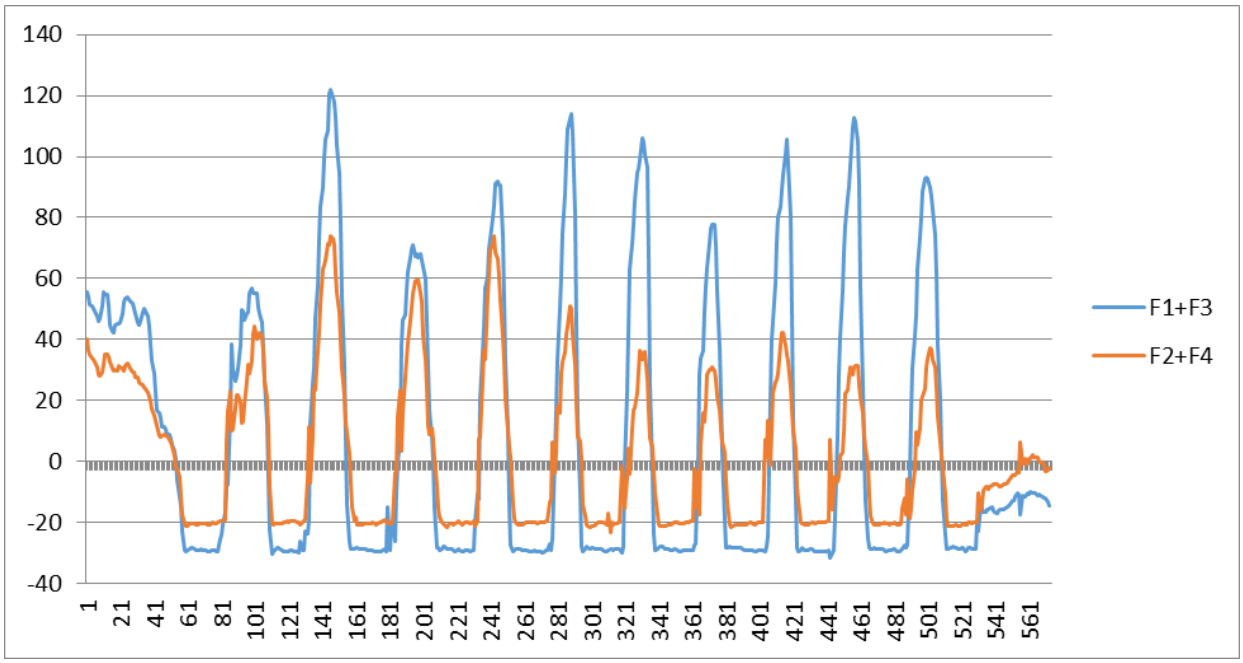

Figure 4.8.6(b): Graph of sum of two forces of Diseased Subject VI

Table 4.8.6: Data of Diseased Subject VI

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Steps	Time (sec)	Right to Left Step Length (in)	Left to Right Step Length (in)	Stride Length (inch)	Condition
6	64	47	5’’3	18.4	7	24	23.2	22.1	45.3	osteoporosis

4.8.6 Analysis:

The graph shows variations’ in the values of the forces in which the F1 force is 14N, F2 force is 40N, F3 force is 49N and F4 force value is 29N. The values of F4 show very variations during the whole walking pattern analysis within the graph. Patient requires more upper limb force to move forward because due to increase in force the velocity decreased. Also that as the age increases the muscle force also increase due to which the velocity decreases and the time increases. As the force of F2 and F4 refer as the right leg of the patient’s body, so it means there is problem in the right leg due to which there is misbalancing in the gait of the patient.

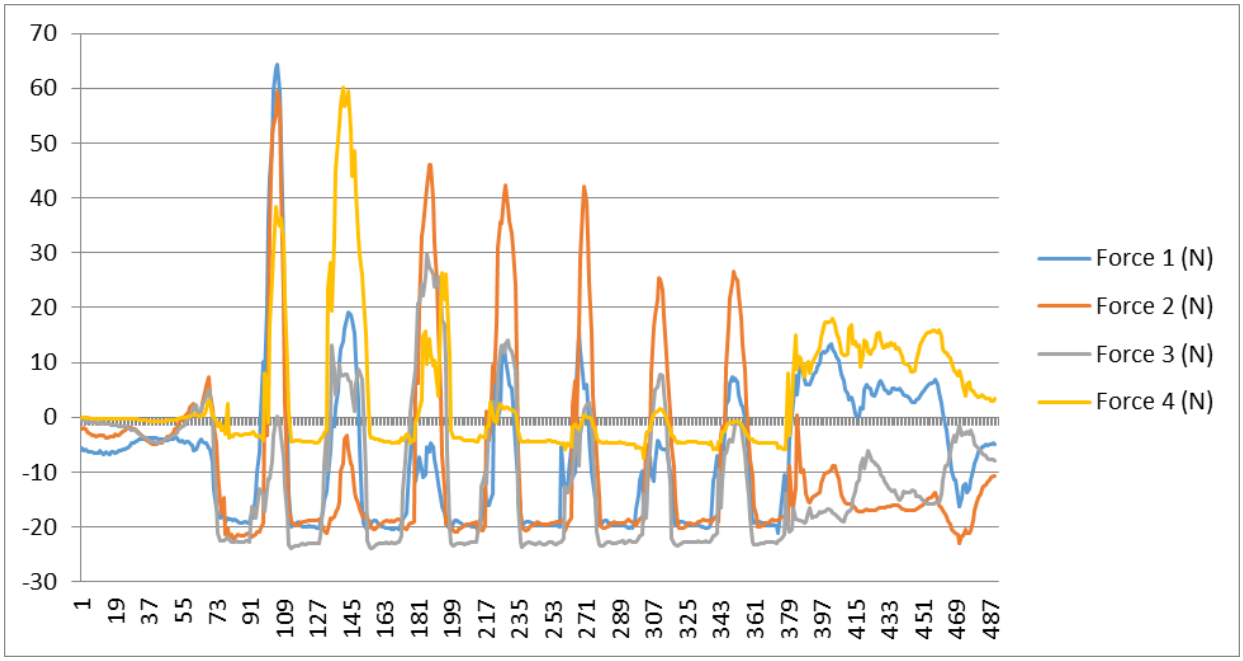

Figure 4.8.7(a): Graph of four forces of Diseased Subject VII [Main problem in Right leg as well as minor problem in Left leg and variations are due to aging]

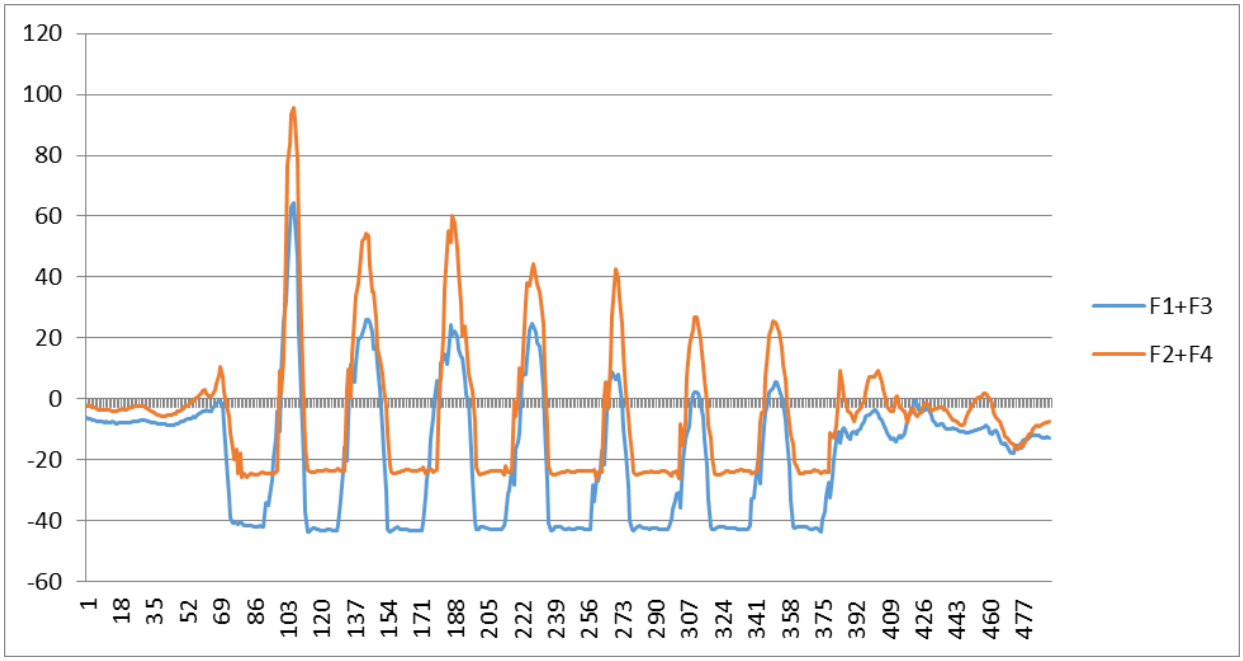

Figure 4.8.7(b): Graph of sum of two forces of Diseased Subject VII

Table 4.8.7: Data of Diseased Subject VII

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Steps	Time (sec)	Right to Left Step Length (in)	Left to Right Step Length (in)	Stride Length (inch)	Condition
7	62	55	5”3	17.7	6	24	15	20.5	35.6	osteoporosis

4.8.7 Analysis:

The increase and decreases of the forces on the graph shows the handling and walking pattern of the patient. First the F1 shows 65N of force, F2 shows 58N, similarly F3 shows 45N and F4 shows 35N. The values of four forces vary very differently and the sum of both sides F1+F3 and F2+F4 are not matching the comparative values of healthy genomic patient’s graph values. Because of non-standard value of F1 and F3, it has been clearly shown that the patient left leg pattern is not normal. It has been proved that, Patient require more upper limb force to move forward because due to increase in force the velocity decrease. Also that as the age increases the muscle force also increase due to which the velocity decrease ad the time increases.

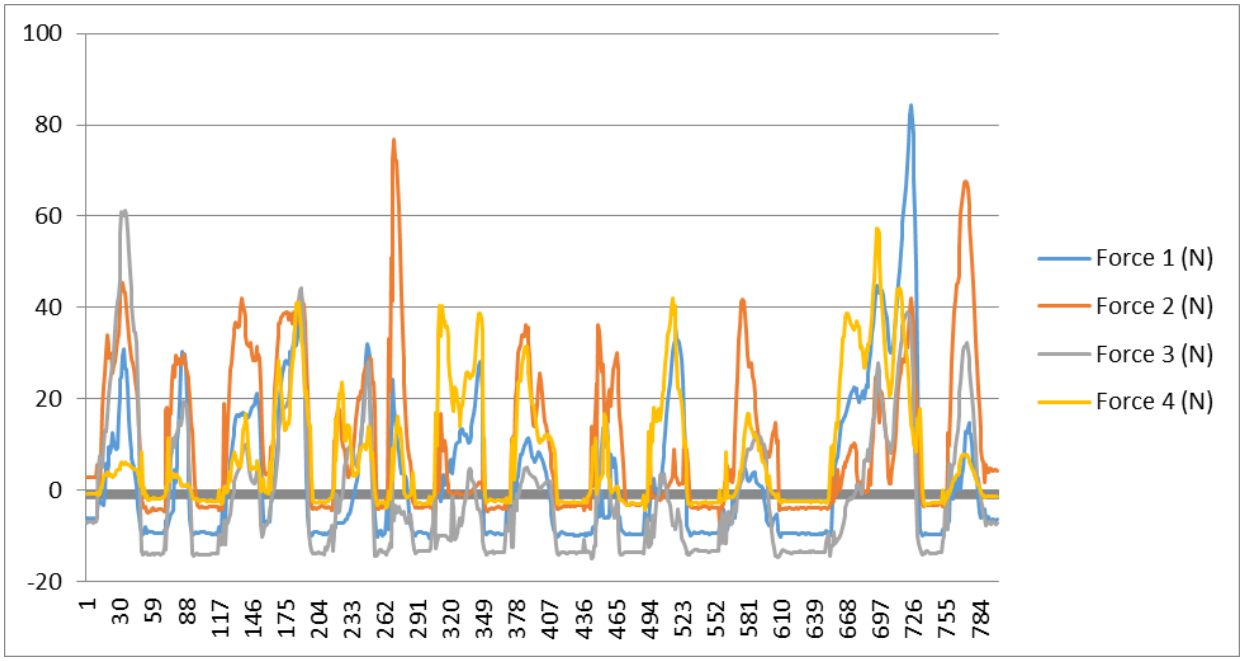

Figure 4.8.8(a): Graph of four forces of Diseased Subject VIII [Slightly problem in Left Leg and the patient was amputee]

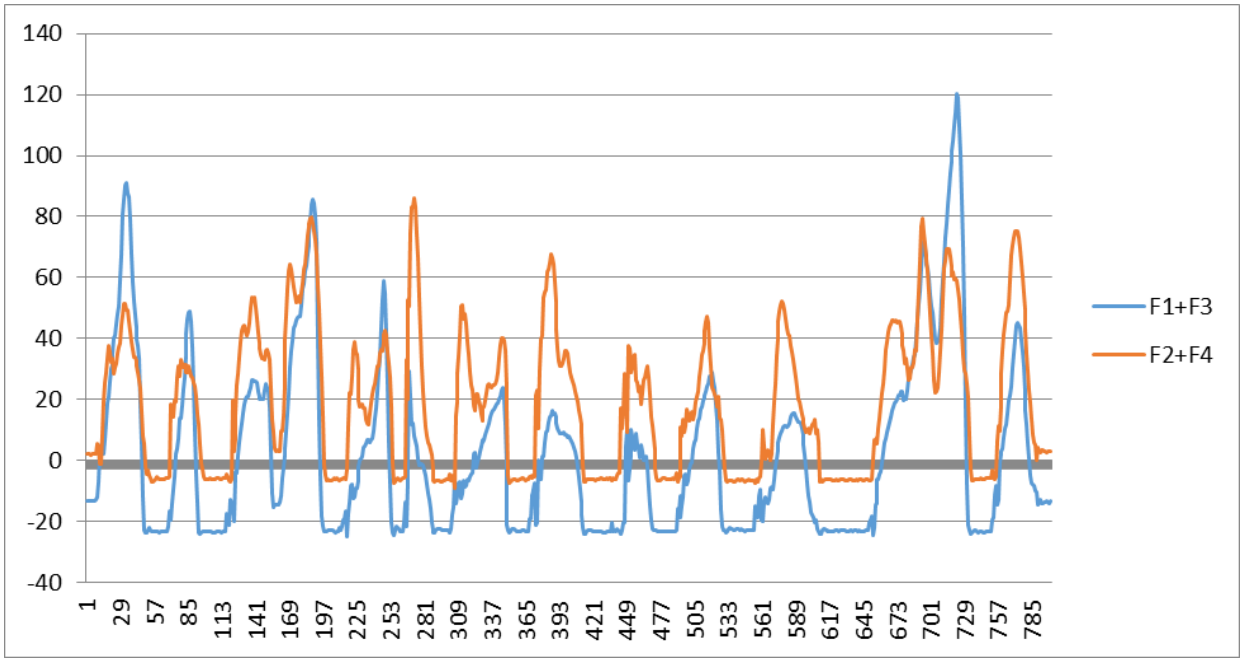

Figure 4.8.8(b): Graph of sum of two forces of Diseased Subject VIII

Table 4.8.8: Data of Diseased Subject VIII

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Steps	Time (sec)	Right to Left Step Length (in)	Left to Right Step Length (in)	Stride Length (inch)	Condition
8	46	42	4”9	20	07	22	16.2	17.1	33.3	osteoporosis

4.8.8 Analysis:

The forces shown in the graph are out of order and no particular pattern has been observed. Force on the F1 sensor is 30N, F2 is 45N, F3 is 60N and F4 is 5N. As the variation has been observed in the sum total of both sides F1+F3 and F2+F4, which means the patient suffer problem in both the legs. Patient required more upper limb force to move forward because due to increase in force the velocity decrease. Also that as the age increases the muscle force also increase due to which the velocity decrease ad the time increases. Also that it has been observed from the steps of the gait pattern that it affects and patient walk slowly as compare to the normal genomic patients.

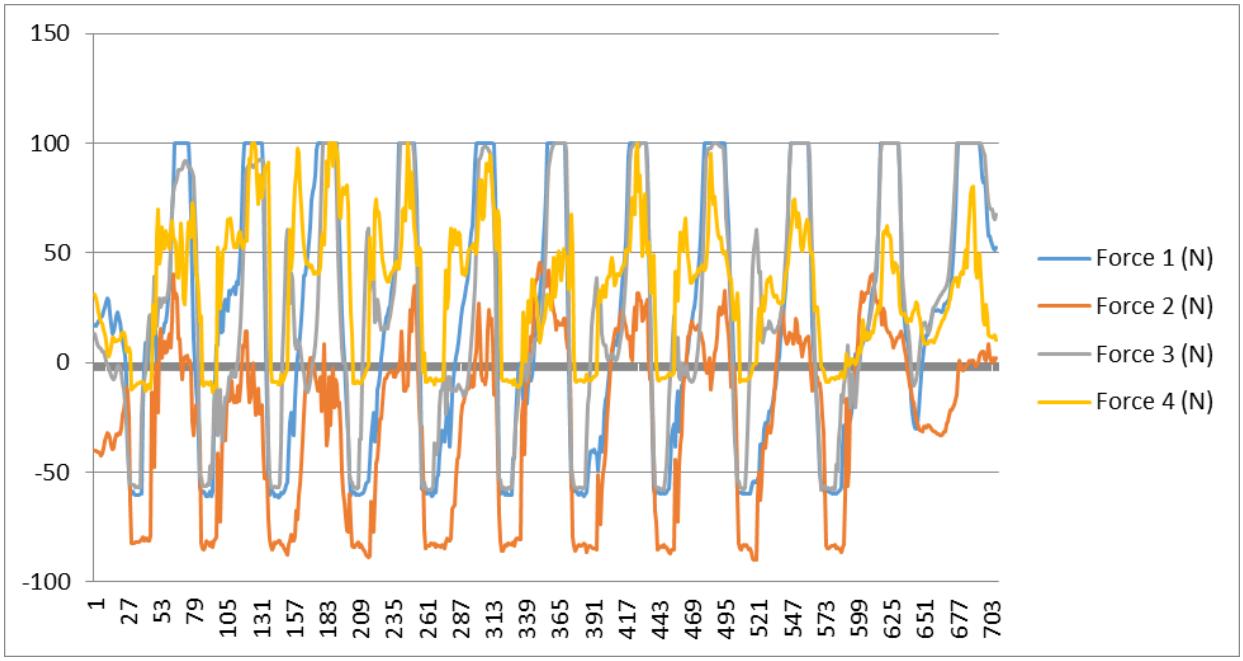

Figure 4.8.9(a): Graph of four forces of Diseased Subject IX [Abnormal pattern in both forces of F2 and F3, problem in both legs]

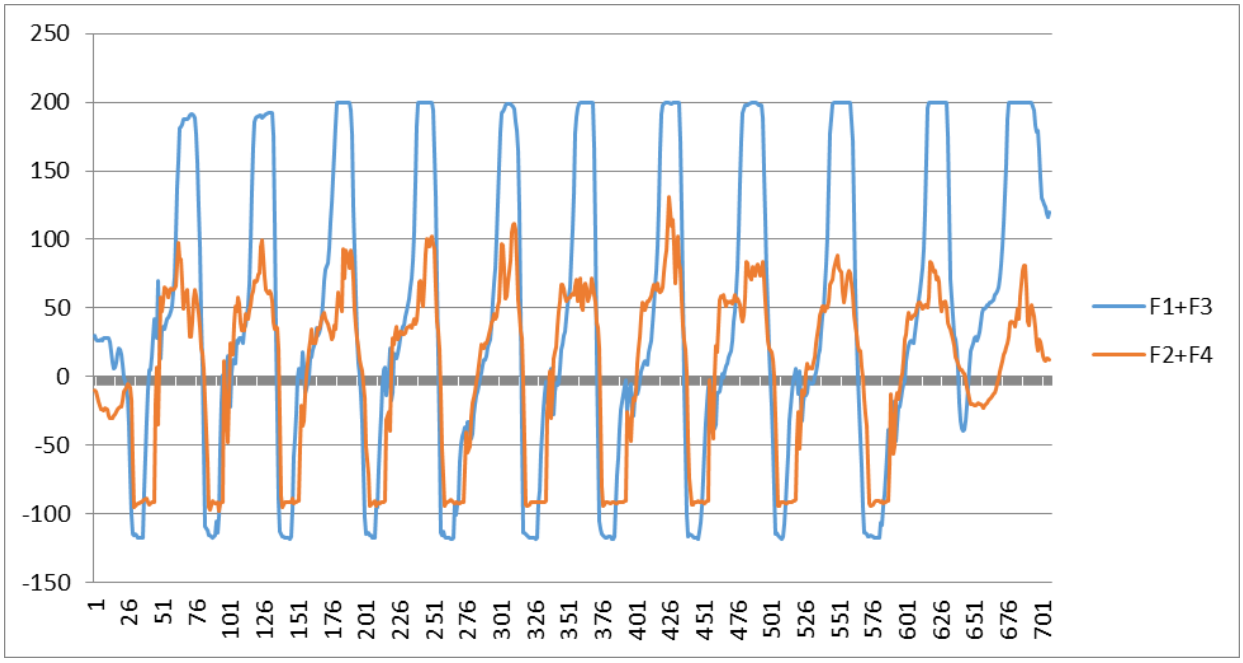

Figure 4.8.9(b): Graph of sum of two forces of Diseased Subject IX

Table 4.8.9: Data of Diseased Subject IX

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Steps	Time (sec)	Right to Left Step Length (in)	Left to Right Step Length (in)	Stride Length (inch)	Condition
9	50	85	5’’11	26.2	08	21	19.5	22.5	42	osteoporosis

4.8.9 Analysis:

The forces shown in the graph are out of order and no particular pattern has been observed. Force on the F1 sensor is 100N, F2 is 40N, F3 is 35N and F4 is 60N. The shows huge variation in the sum total mean of F2 and F4, which the right side upper limb force of the body. Due to this variation in right side values of forces we can predict that the patient right leg has been affected by the osteoporosis. Also from the above table we can see that patient required more time to travel and the steps which he completed is also less as compare to the healthy genomic patients. Patient required more upper limb force to move forward because due to increase in force the velocity decreased. Also that as the age increases the muscle force also increase due to which the velocity decrease ad the time increases.

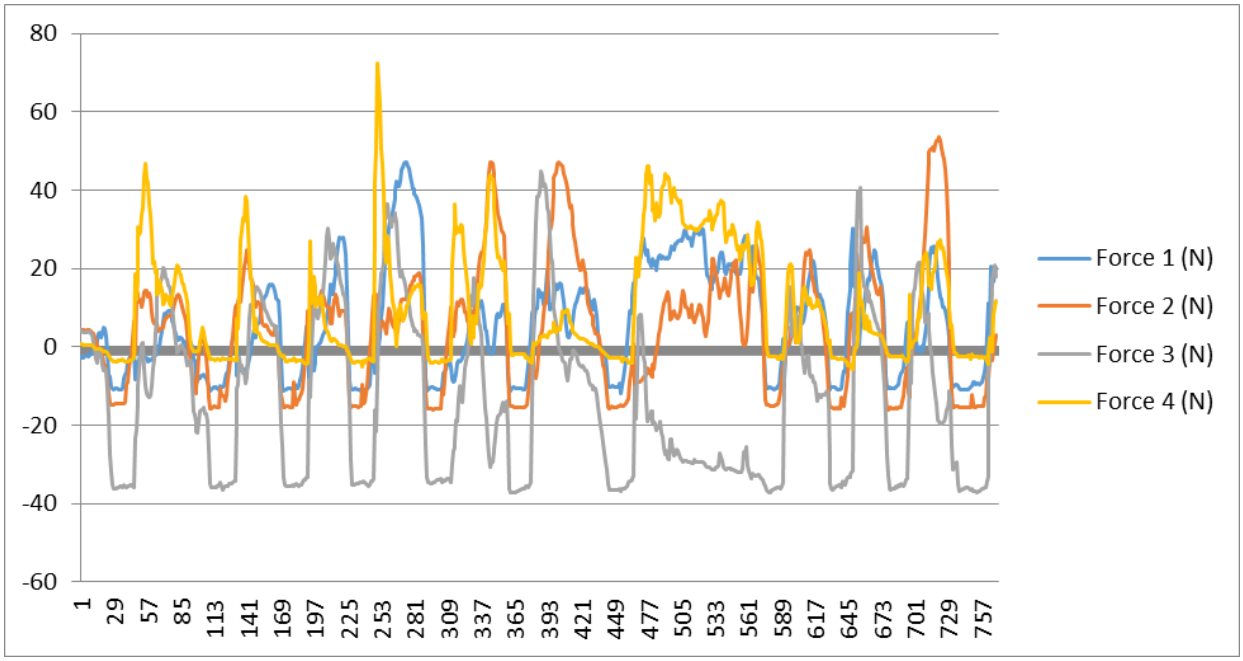

Figure 4.8.10(a): Graph of four forces of Diseased Subject X [Severe condition in both leg due to unbalanced legs]

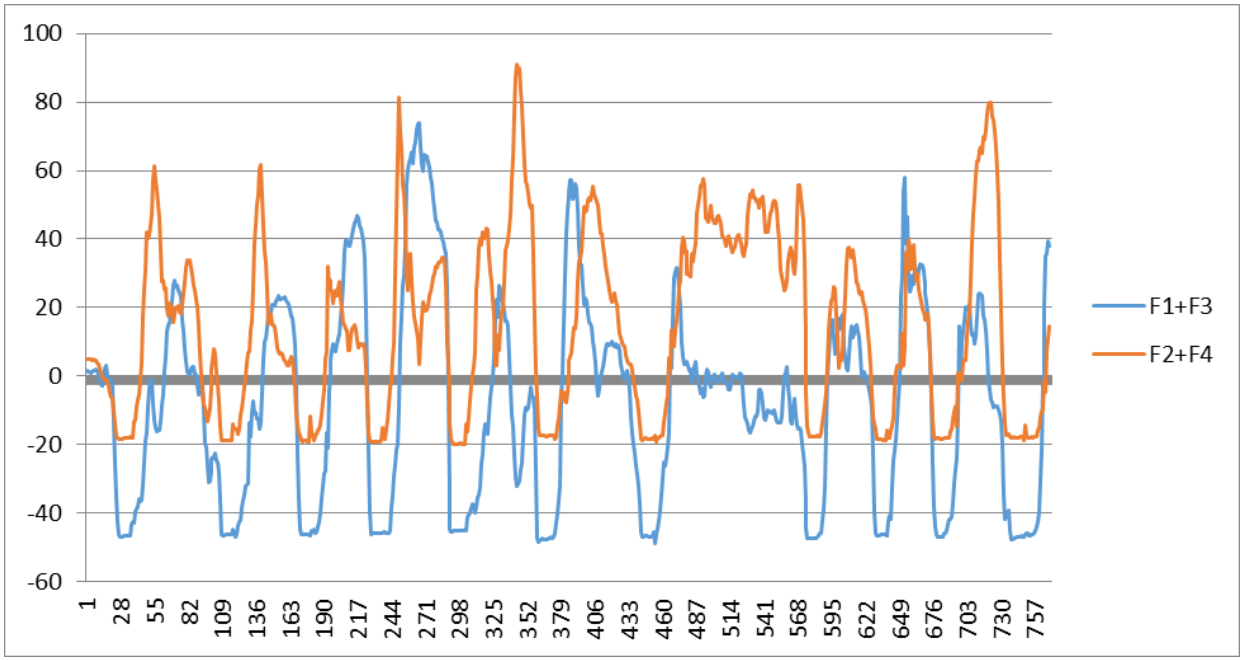

Figure 4.8.10(b): Graph of sum of two forces of Diseased Subject X

Table 4.8.10: Data of Diseased Subject X

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Steps	Time (sec)	Right to Left Step Length (in)	Left to Right Step Length (in)	Stride Length (inch)	Condition
10	60	50	5’’6	17.7	6	24	15.	20.5	35.6	osteoporosis

4.8.10 Analysis:

The disparity has been observed all over the values of forces, in which F1 has 20N, F2 has 20N, F3 has 15N and F4 has 45N at the initial step of the gait analysis. Also that the patient required more time to complete its steps as we have seen in the table that in 24sec he just completed 6steps. Furthermore, the sum force of F1+F3 and F2+F4 are out of order as compare to the normal genomic patients. Patient require more upper limb force to move forward because due to increase in force the velocity decrease. Also that as the age increases the muscle force also increase due to which the velocity decrease ad the time increases.

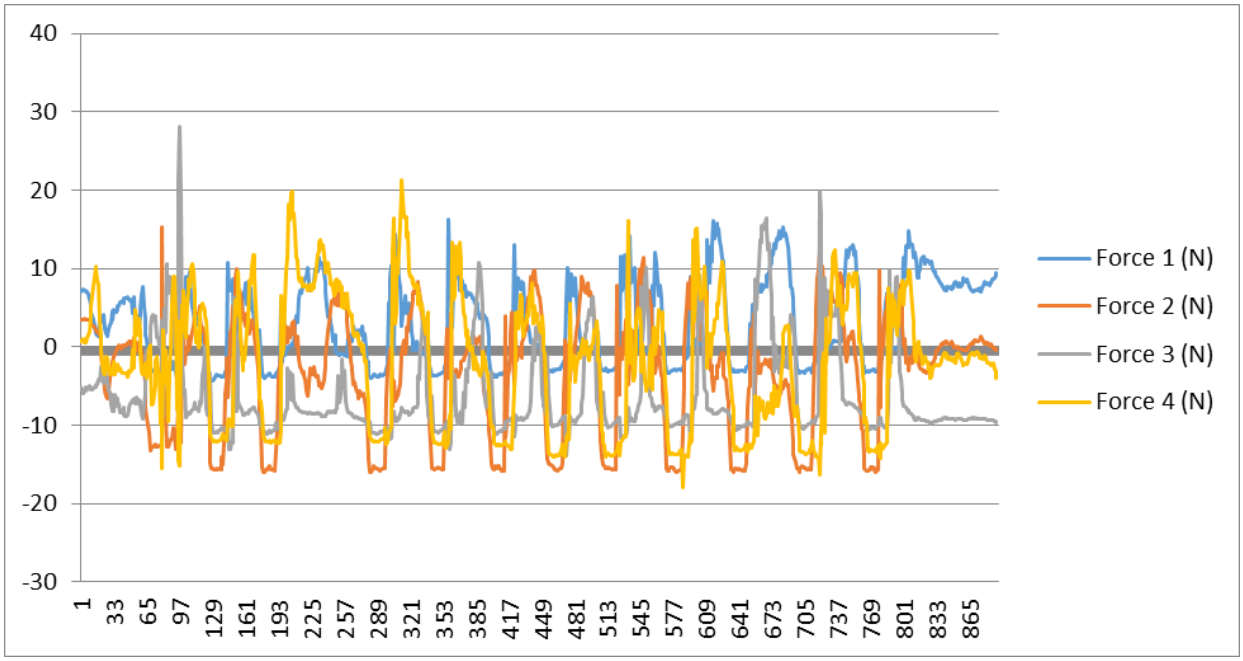

Figure 4.8.11(a): Graph of four forces of Diseased Subject XI [Slightly problem in F2 means in right leg and variations due to genomic disease]

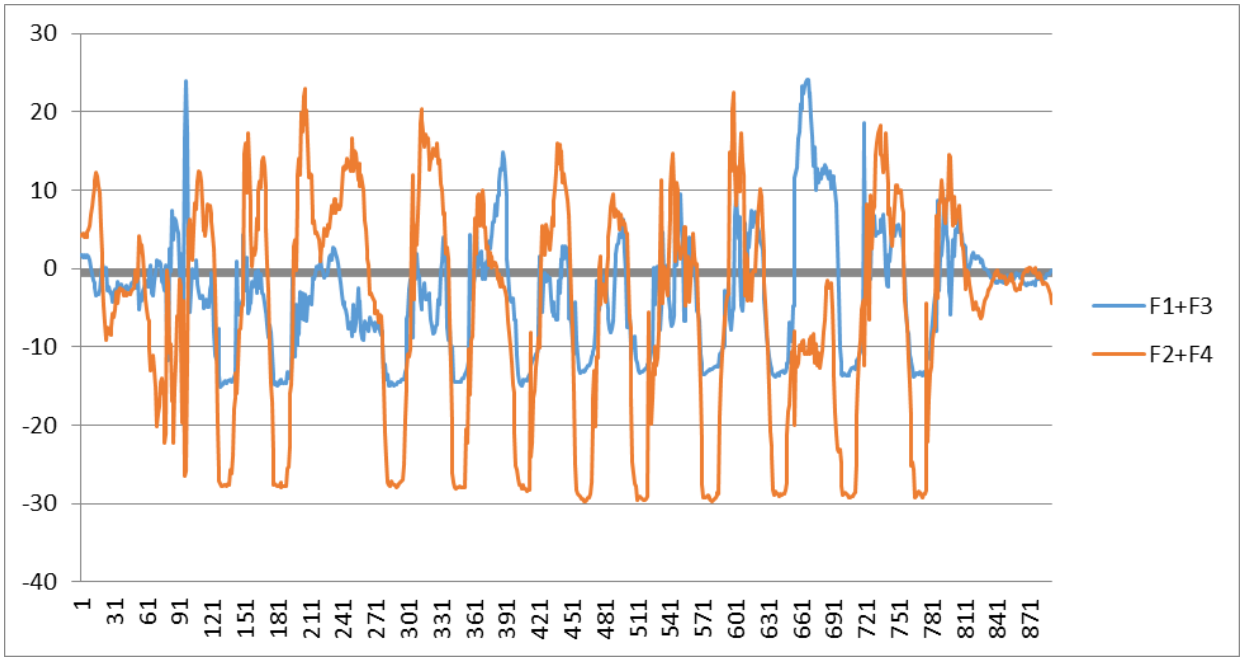

Figure 4.8.11(b): Graph of sum of two forces of Diseased Subject XI

Table 4.8.11: Data of Diseased Subject XI

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Steps	Time (sec)	Right to Left Step Length (in)	Left to Right Step Length (in)	Stride Length (inch)	Condition
11	46	42	4’’9	20	07	22	16.2	17.1	33.3	osteoporosis

4.8.11 Analysis:

The increase and decreases of the forces on the graph shows the handling and walking pattern of the patient. First the F1 shows 9N, F2 shows 15N, similarly F3 shows 6N and F4 shows 10N. Majority of the sum values of F2+F4 are below the 0N and not above the 25N, it means the balancing force of the body is not applied properly by the patient and it has difficulty in walking due to its right leg. We have noted that, Patient require more upper limb force to move forward because due to increase in force the velocity decrease. Also that as the age increases the muscle force also increase due to which the velocity decrease ad the time increases.

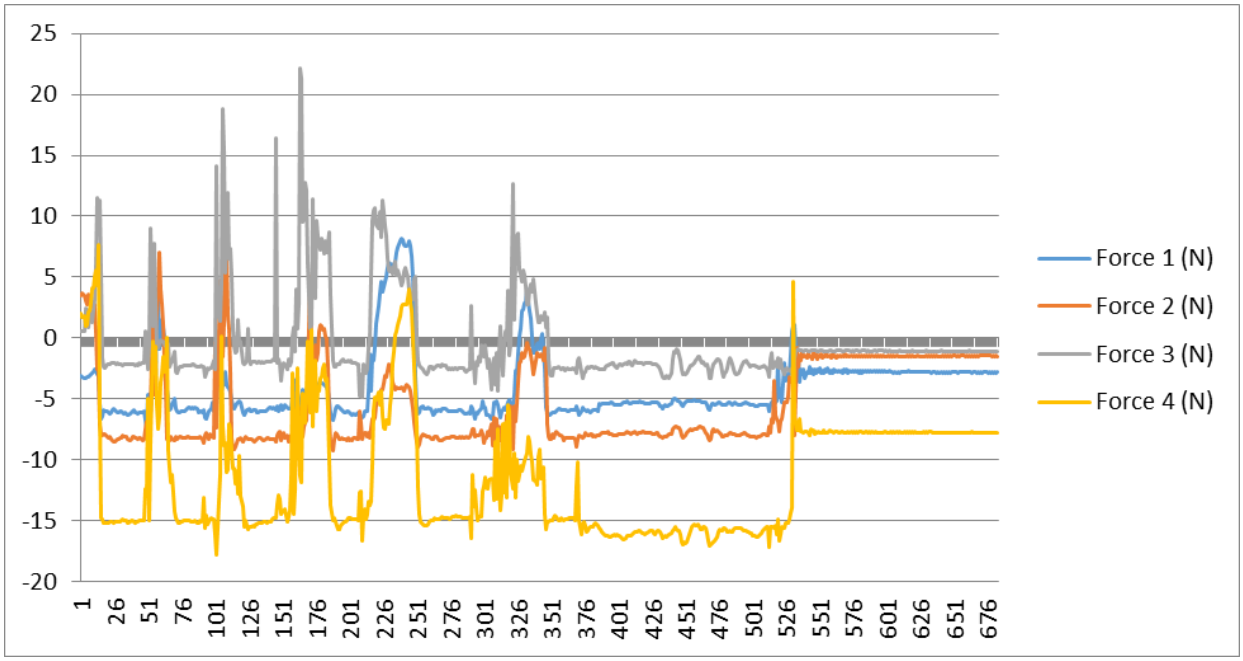

Figure 4.8.12(a): Graph of four forces of Diseased Subject XII [Severe problem in both right leg and left leg]

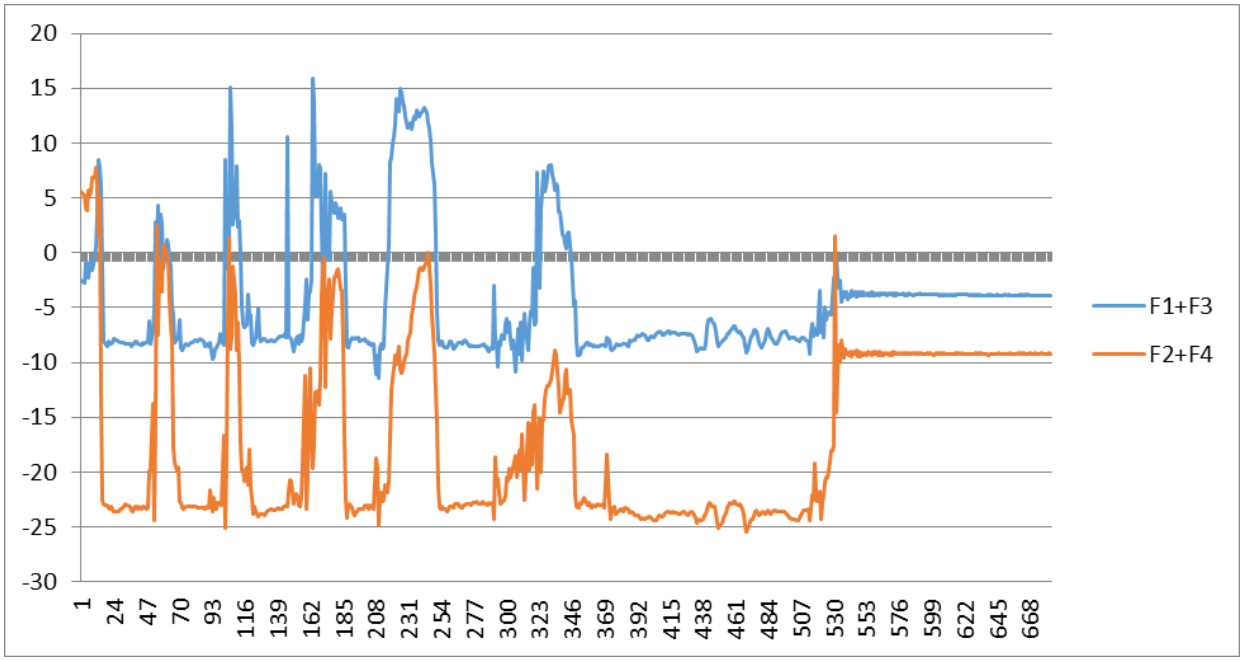

Figure 4.8.12(b): Graph of sum of two forces of Diseased Subject XII

Table 4.8.12: Data of Diseased Subject XII

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Steps	Time (sec)	Right to Left Step Length (in)	Left to Right Step Length (in)	Stride Length (inch)	Condition
12	60	48	5’’1	20	07	24	22.2	18.5	40.7	osteoporosis

4.8.12 Analysis:

At the first step the value of F1 increase to 6N, F2 increase also to the 6N, F3 increases to the 12N and F4 to the 9N. When the patient walks and apply force the peaks touches its maximum heights and when it releases its force than the peaks decreases. Due to the disease condition of osteoporosis the gait pattern will change at every point also that the sum forces of F1+F3 and F2+ F4, both legs have the severe osteoporotic condition and because of which the patient is not able to walk properly. Furthermore, the patient requires more time to walk and complete its walking steps as compare to the normal genomic patients.

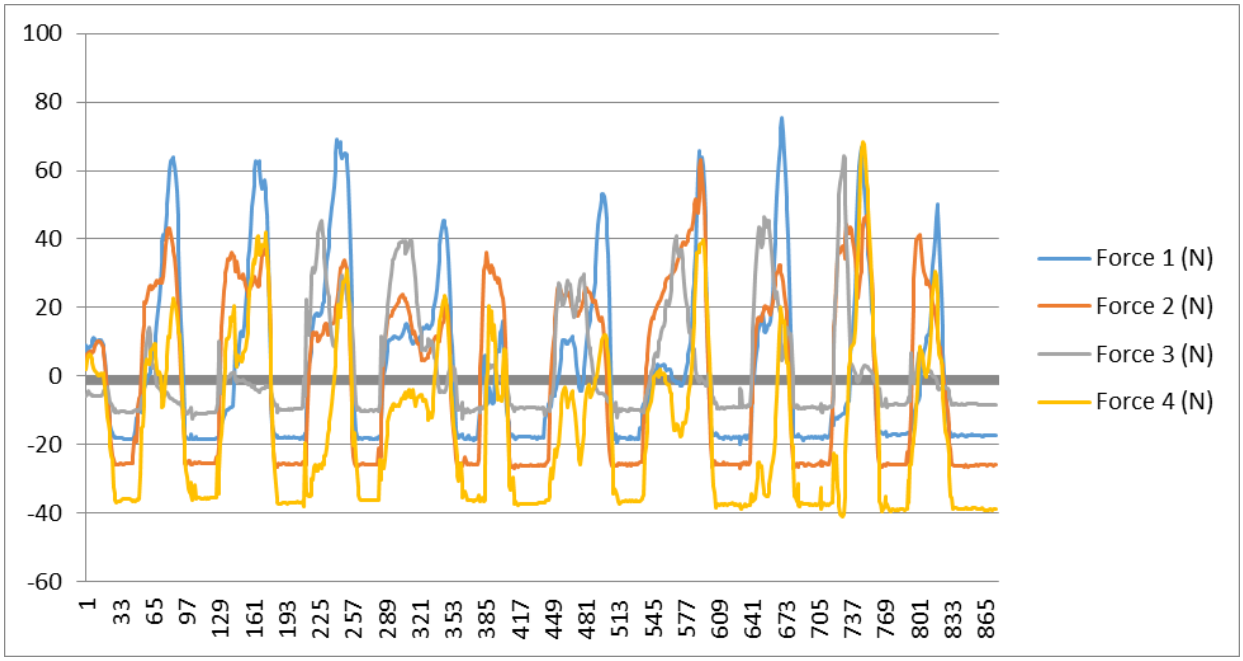

Figure 4.8.13(a): Graph of four forces of Diseased Subject XIII [Problem in F1 and F3 i.e. Left leg and variations due to aging]

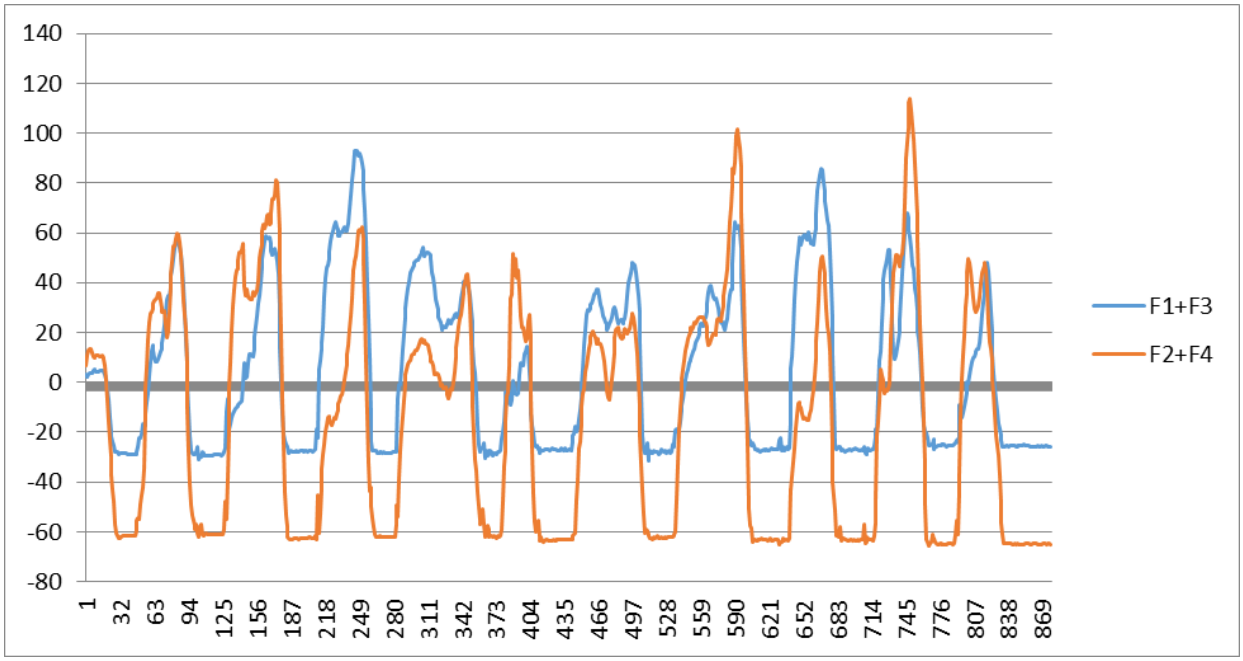

Figure 4.8.13(b): Graph of sum of two forces of Diseased Subject XIII

Table 4.8.13: Data of Diseased Subject XIII

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Steps	Time (sec)	Right to Left Step Length (in)	Left to Right Step Length (in)	Stride Length (inch)	Condition
13	30	58	5’’3	22.7	08	22	18.5	16	34.5	osteoporosis

4.8.13 Analysis:

The graph shows the discrete values of the forces, majority of the forces shown in the graph are out of order and no particular pattern has been observed. Force on the F1 sensor is 62N, F2 is 41N, F3 is 17N and F4 is 22N. Because of the disease the forces on the left side are unequal, which includes F1+F3 sum force. Due to this variation in left side values, we can predict that the patient left leg has been effected by the osteoporosis. Also from the above table we can see that patient required more time to travel and the steps which he completed is also less as compare to the healthy genomic patients.

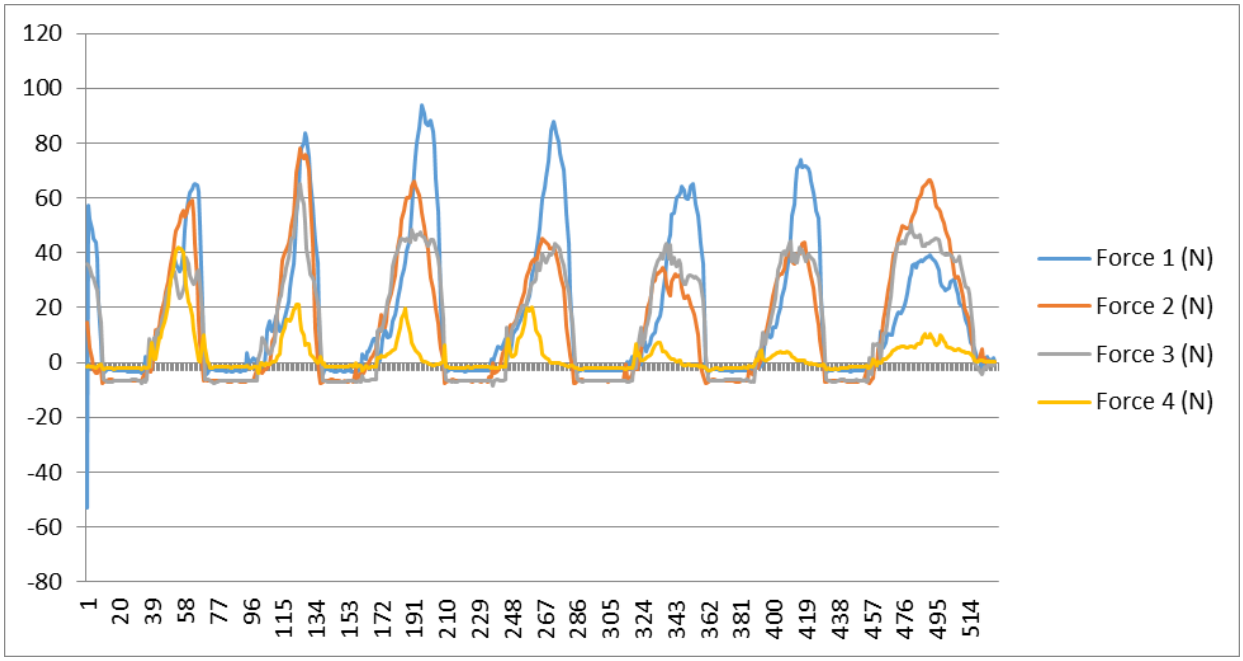

Figure 4.8.14(a): Graph of four forces of Diseased Subject XIV [Severe problem in all forces i.e. problem in whole walking pattern due to disability]

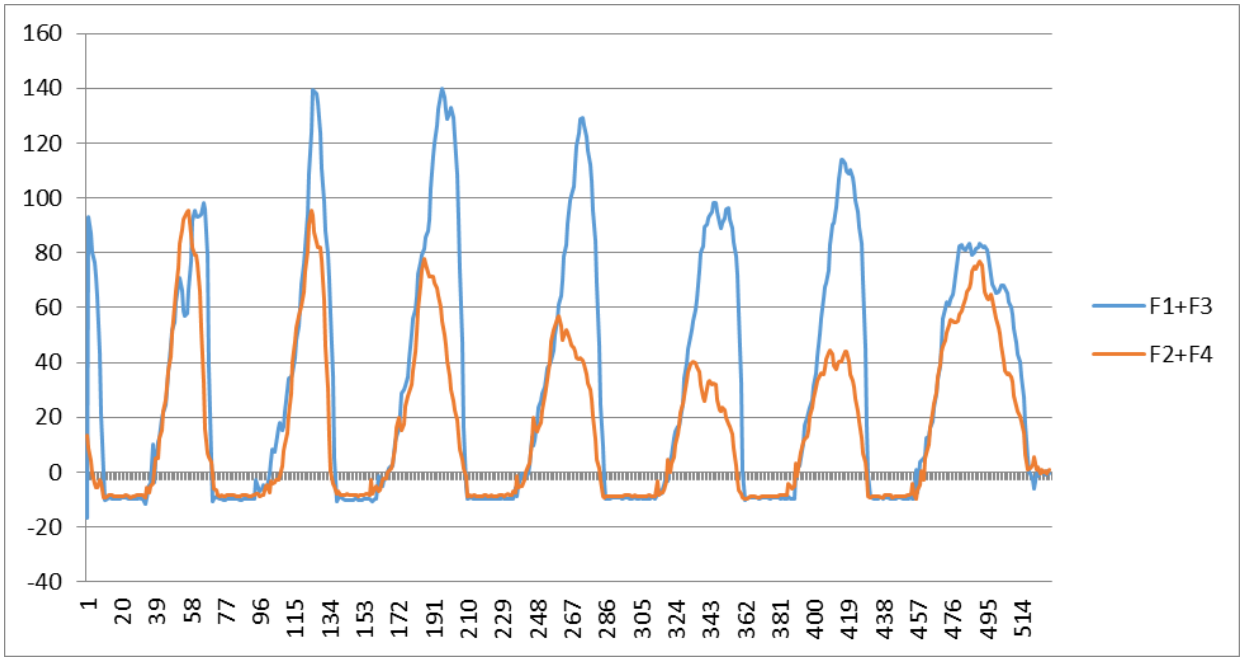

Figure 4.8.14(b): Graph of sum of two forces of Diseased Subject XIV

Table 4.8.14: Data of Diseased Subject XIV

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Steps	Time (sec)	Right to Left Step Length (in)	Left to Right Step Length (in)	Stride Length (inch)	Condition
14	72	70	5’’5	25.7	07	27	1	17	33	osteoporosis

4.8.14 Analysis:

The values of the graph show the discrete points forces of the body, F1 is 55N, F2 is 55N, F3 is 30N and F4 is 40N. Because of the disease the forces on the right side are unequal, which includes F2+F4 sum force. Patient require more upper limb force to move forward because due to increase in force the velocity decrease. Also that as the age increases the muscle force also increase due to which the velocity decrease ad the time increases. Due to this variation in right side values, we can predict that the patient right leg has been affected by the osteoporosis. Also from the above table we can see that patient required more time to travel and the steps which he completed is also less as compare to the healthy genomic patients.

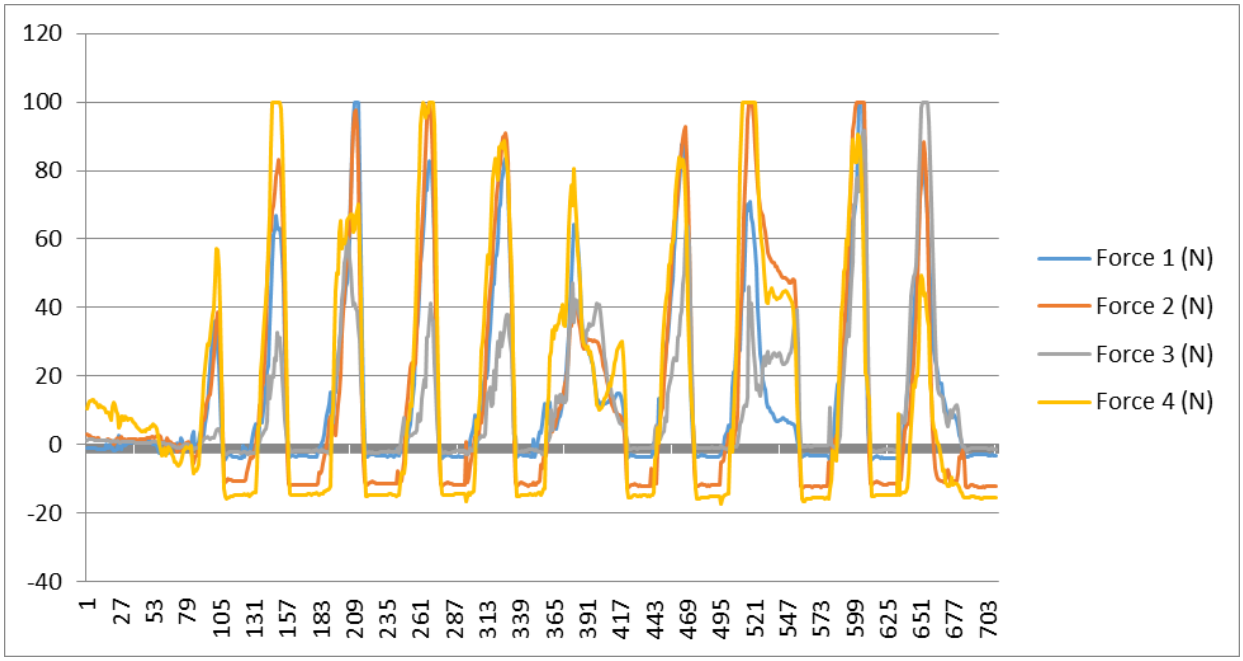

Figure 4.8.15(a): Graph of four forces of Diseased Subject XV [Slightly problem in Left leg i.e. F1 and F3 and also variations due to newly fixed orthosis]

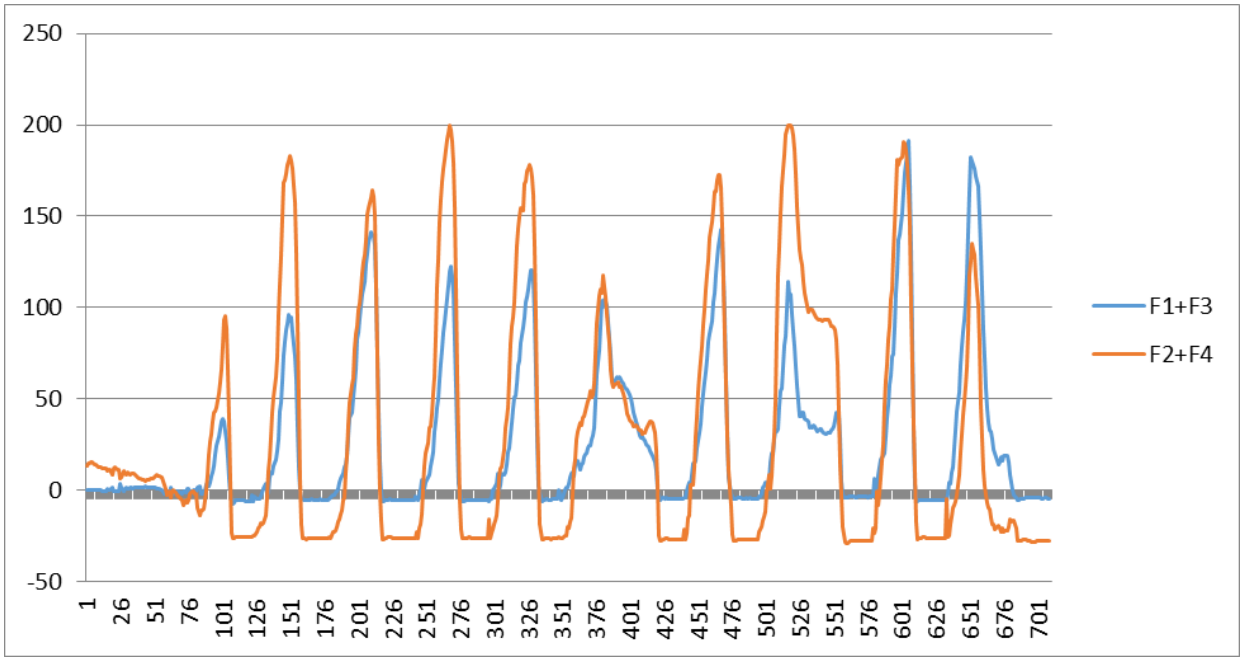

Figure 4.8.15(b): Graph of sum of two forces of Diseased Subject XV

Table 4.8.15: Data of Diseased Subject XV

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Steps	Time (sec)	Right to Left Step Length (in)	Left to Right Step Length (in)	Stride Length (inch)	Condition
15	39	55	5’’1	22.9	6	23	17	23	40	osteoporosis

4.8.15 Analysis:

At the first step the value of F1 increase to 30N, F2 increase also to the 39N, F3 increases to the 38N and F4 to the 58N. When the patient walks and apply force the peaks touches its maximum heights and when it releases its force than the peaks decreases. Due to the disease condition of osteoporosis the gait pattern will change at every point, as the sum forces of F1+F3 are not in periodic pattern, left legs have the severe osteoporotic condition and because of which the patient is not able to walk properly. Furthermore, the patient requires more time to walk and complete its walking steps as compare to the normal genomic patients and patient require more upper limb force to move forward because due to increase in force the velocity decreased. Also that as the age increases the muscle force also increase due to which the velocity decrease ad the time increases.

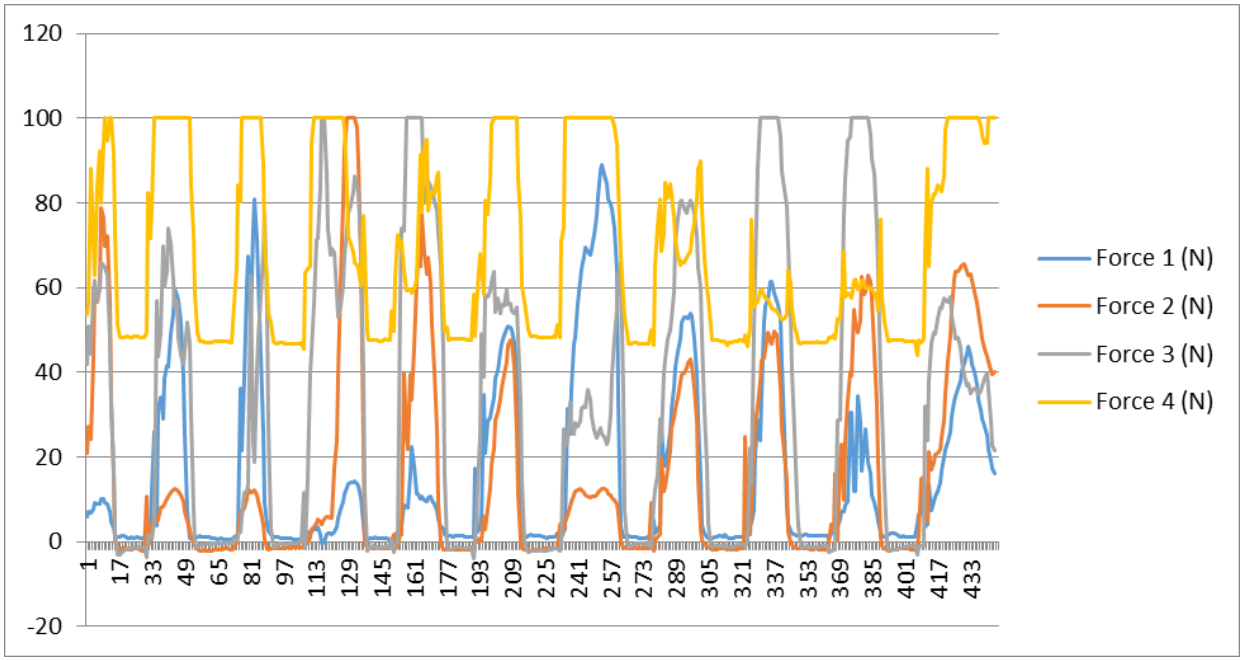

Figure 4.8.16(a): Graph of four forces of Diseased Subject XVI [Severe problem in both the legs of the body due to accident]

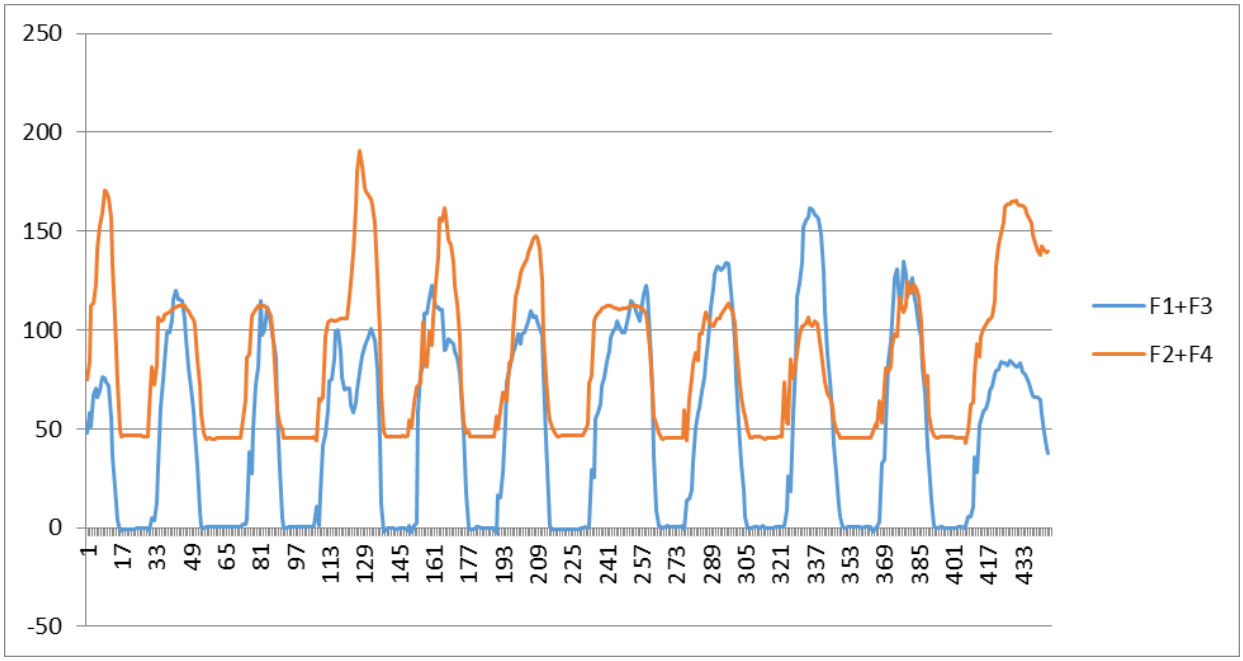

Figure 4.8.16(b): Graph of sum of two forces of Diseased Subject XVI

Table 4.8.16: Data of Diseased Subject XVI

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Steps	Time (sec)	Right to Left Step Length (in)	Left to Right Step Length (in)	Stride Length (inch)	Condition
16	54	77	6	23	08	21	18	17	35	osteoporosis

4.8.16 Analysis:

The increase and decreases of the forces on the graph shows the walking pattern of the patient. When the patient moved forward the peaks reaches its maximum heights and when he stopped, the peaks decreases. Initially the F1 force reaches up to 65N, F2 up to 78N, F3 reaches 65N and F4 100N. Both the mean values of F1, F2, F3 and F4 are not similar to the results of the normal genomic patients. Due to which we are able to predict that patient suffer problem in both the legs. Patient require more upper limb force to move forward because due to increase in force the velocity decrease. Also that as the age increases the muscle force also increase due to which the velocity decrease ad the time increases.

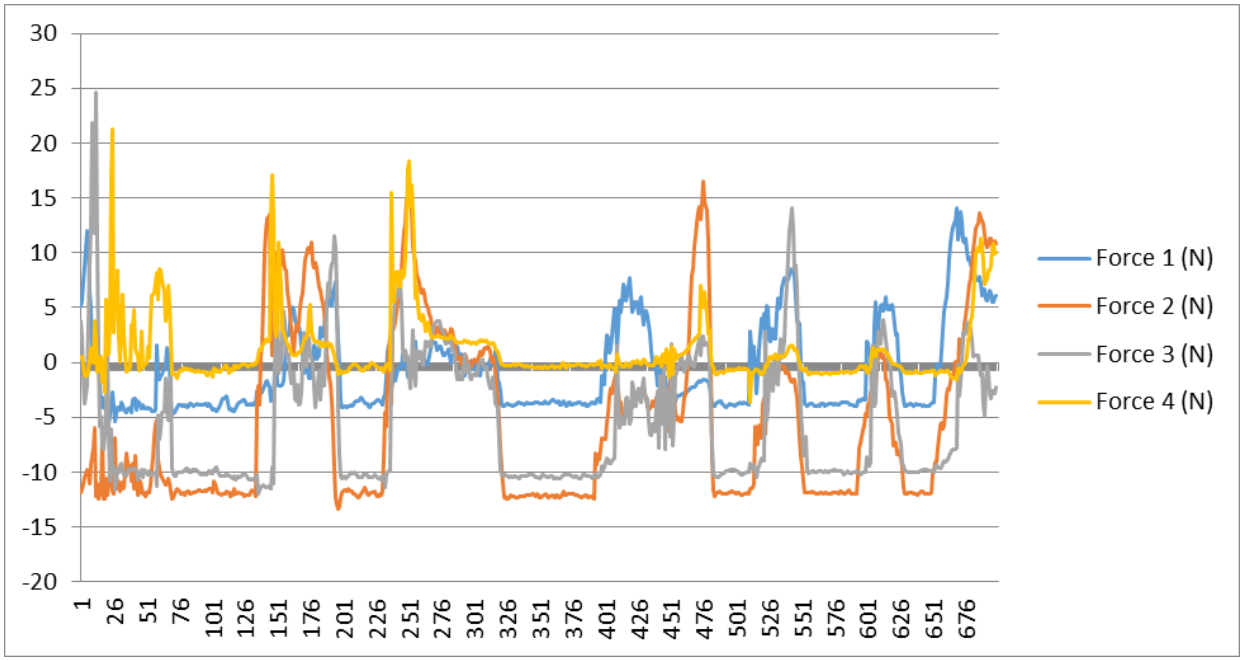

Figure 4.8.17(a): Graph of four forces of Diseased Subject XVII [severe problem in Left leg and slightly problem in Right leg]

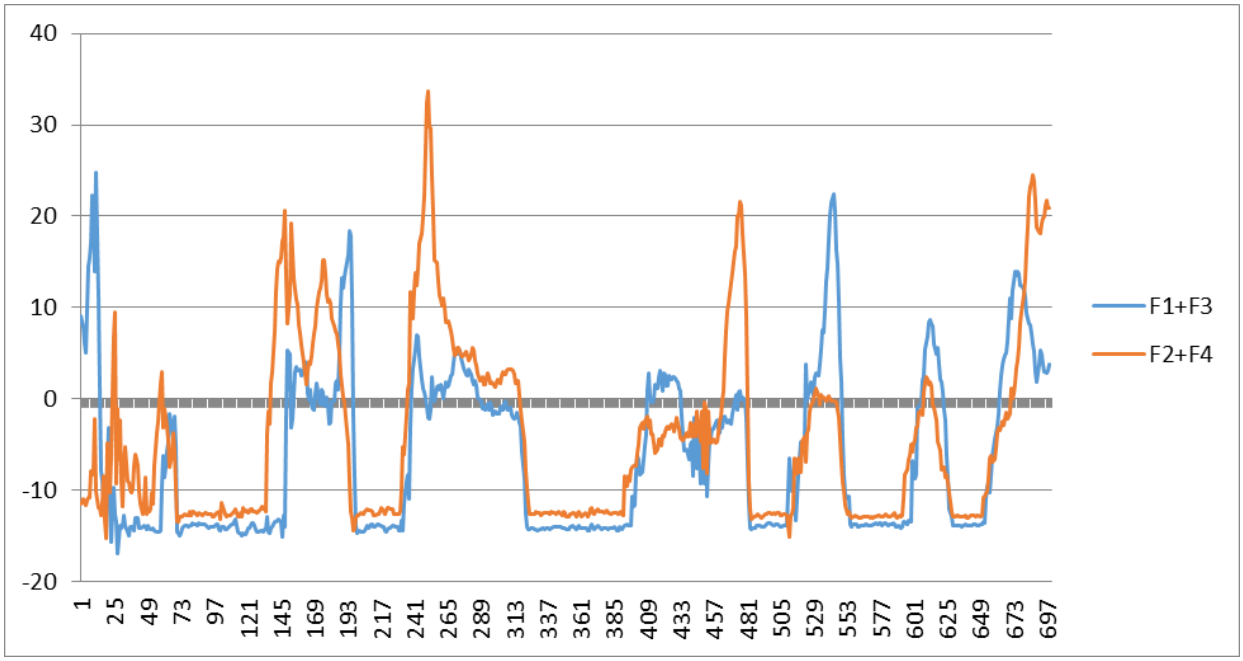

Figure 4.7.17(b): Graph of sum of two forces of Diseased Subject XVII

Table 4.8.17: Data of Diseased Subject XVII

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Steps	Time (sec)	Right to Left Step Length (in)	Left to Right Step Length (in)	Stride Length (inch)	Condition
17	70	58	5’’7	20.1	09	25	17.2	19.5	36.7	osteoporosis

4.8.17 Analysis:

The increase and decreases of the forces on the graph shows the walking pattern of the patient. When the patient moved forward the peaks reaches its maximum heights and when he stopped the peaks decreases. Initially the F1 force reaches up to 12N, F2 up to 12N, F3 reaches 20N and F4 is 21N. Both the mean values of F1, F2, F3 and F4 are not similar to the results of the normal genomic patients. Due to which we are able to predict that patient suffer problem in both the legs. Patient required more upper limb force to move forward because due to increase in force the velocity decreased. Also that as the age increases the muscle force also increase due to which the velocity decrease ad the time increases.

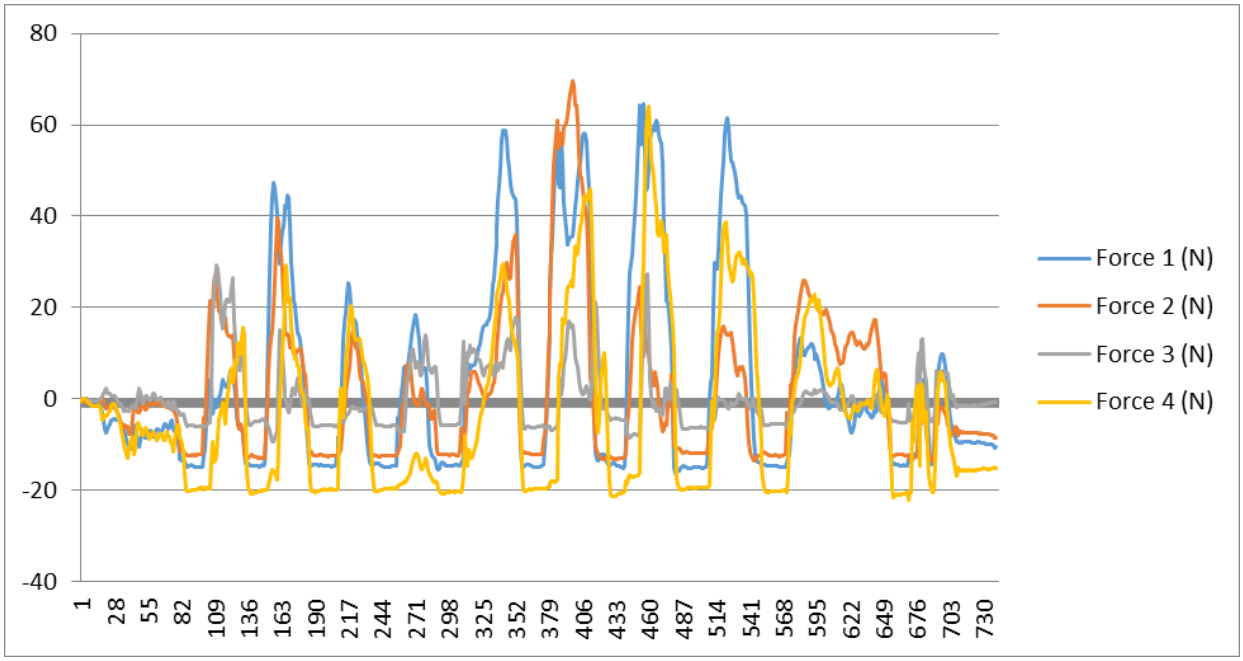

Figure 4.8.18(a): Graph of four forces of Diseased Subject XVIII [Problem in F2 and F4 means problem in Right leg]

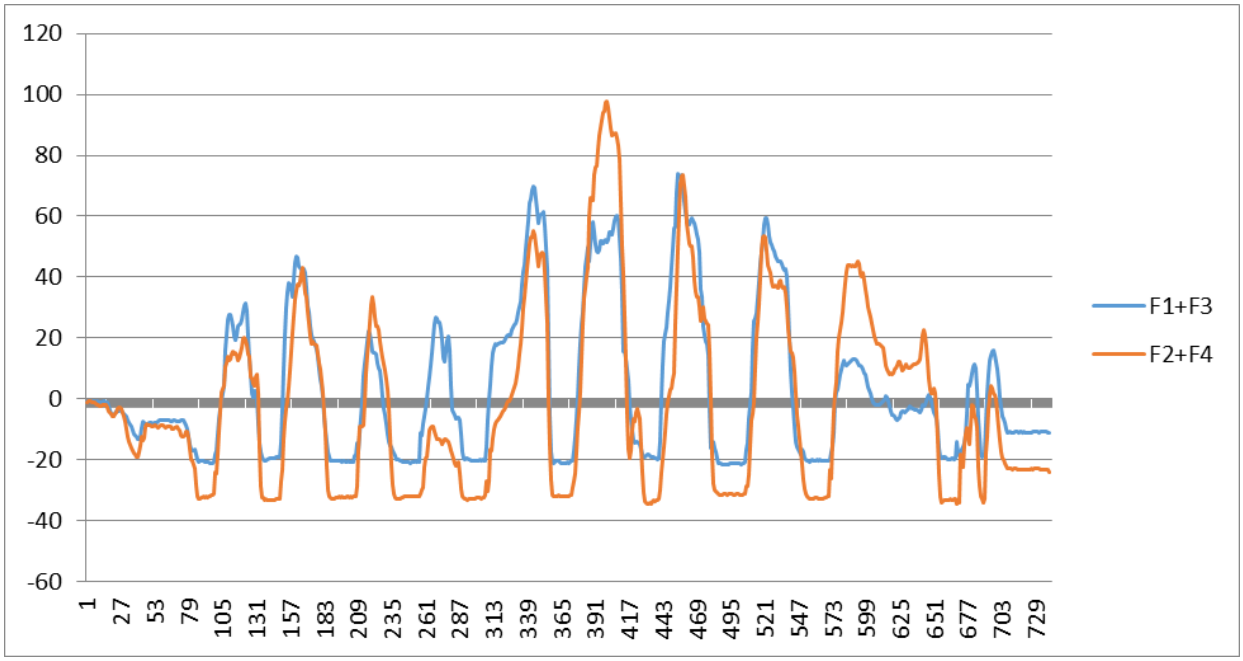

Figure 4.8.18(b): Graph of sum of two forces of Diseased Subject XVIII

Table 4.8.18: Data of Diseased Subject XVIII

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Steps	Time (sec)	Right to Left Step Length (in)	Left to Right Step Length (in)	Stride Length (inch)	Condition
18	70	61	5’’2	24.7	08	27	18.5	21.2	39.7	osteoporosis

4.8.18 Analysis:

The increase and decreases of the forces on the graph shows the walking pattern of the patient. When the patient move forward the peaks reaches its maximum heights and when he stop the peaks decreases. Initially the F1 force reaches up to 5N, F2 up to 21N, F3 reaches 25N and F4 18N. Both the mean values of F1, F2, F3 and F4 are not similar to the results of the normal genomic patients. Due to which we are able to predict that patient suffer problem in both the legs. Due these results in the graphs the two relation has been proved, which are Patient require more upper limb force to move forward because due to increase in force the velocity decrease and second is that when the age increases the muscle force also increase due to which the velocity decrease and the time increases.

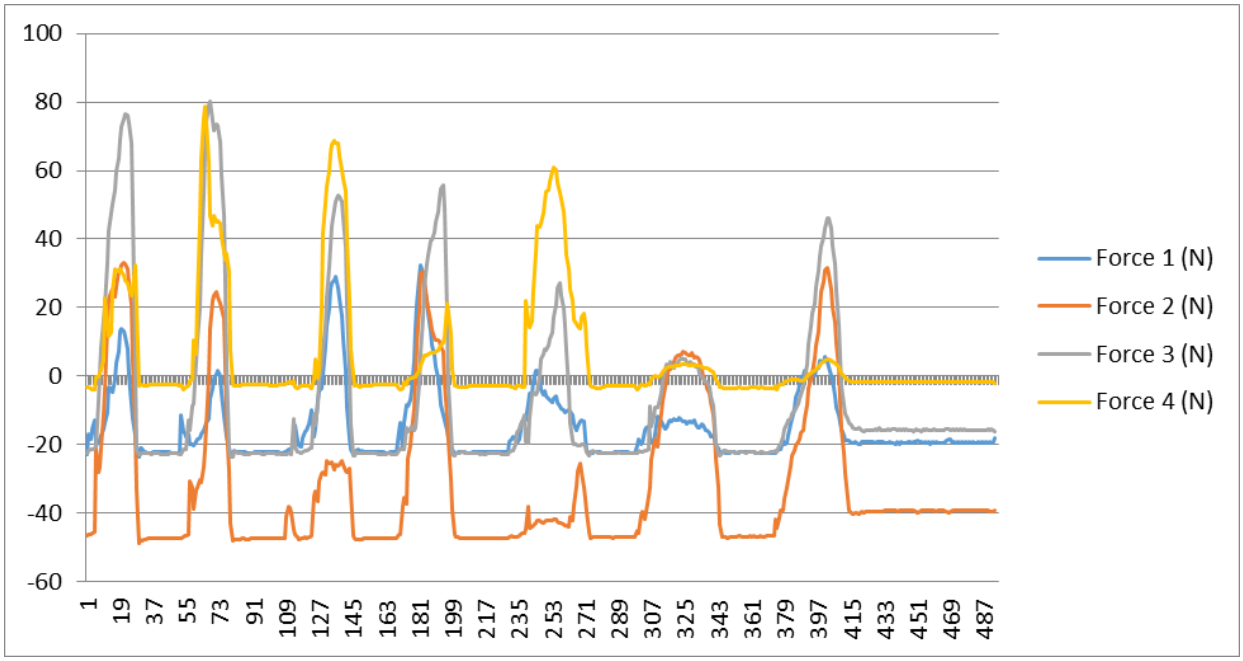

Figure 4.8.19(a): Graph of four forces of Diseased Subject XIX [slightly problem in F1 and F3 means Left side of the leg due to orthosis on left side]

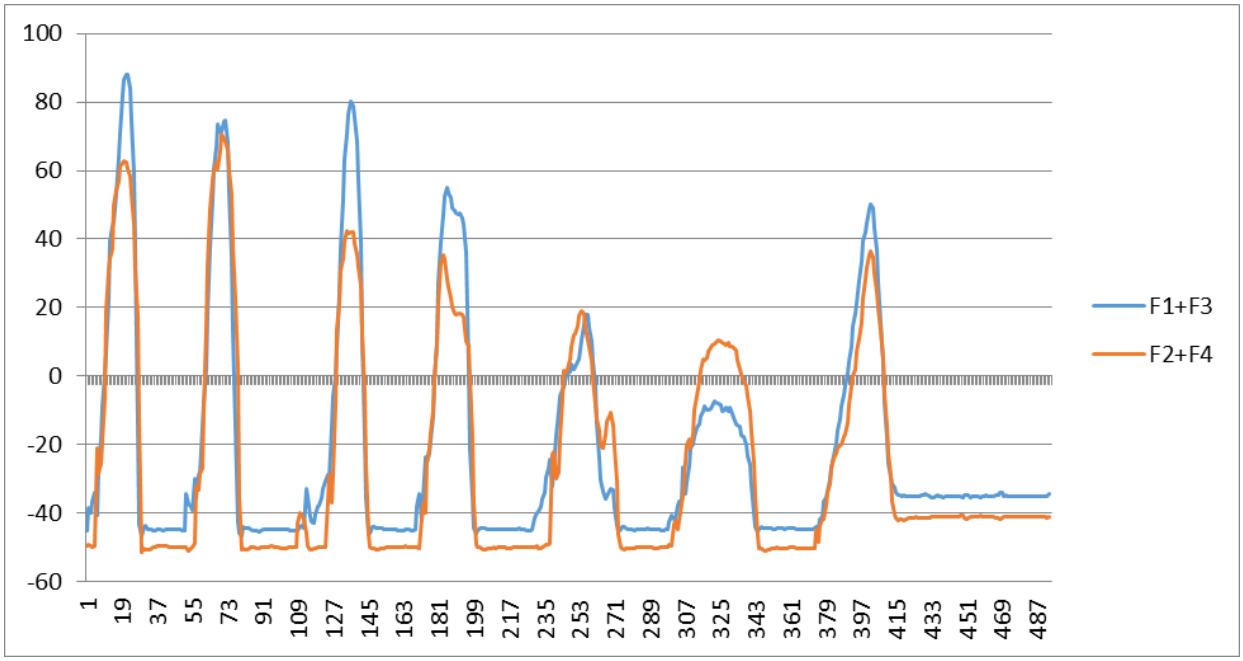

Figure 4.8.19(b): Graph of sum of two forces of Diseased Subject XIX

Table 4.8.19: Data of Diseased Subject XIX

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Steps	Time (sec)	Right to Left Step Length (in)	Left to Right Step Length (in)	Stride Length (inch)	Condition
19	54	77	6	23	08	21	18	17	35	osteoporosis

4.8.19 Analysis:

The increase and decreases of the forces on the graph shows the walking pattern of the patient. When the patient move forward the peaks reaches its maximum heights and when he stop the peaks decreases. Initially the F1 force reaches up to 15N, F2 up to 30N, F3 reaches 78N and F4 30N. The mean values of F1 and F3 are not similar to the results of the normal genomic patients. Due to which we are able to predict that patient suffer problem in left leg. It has been proved that: Patient require more upper limb force to move forward because due to increase in force the velocity decrease. Also that as the age increases the muscle force also increase due to which the velocity decrease ad the time increases.

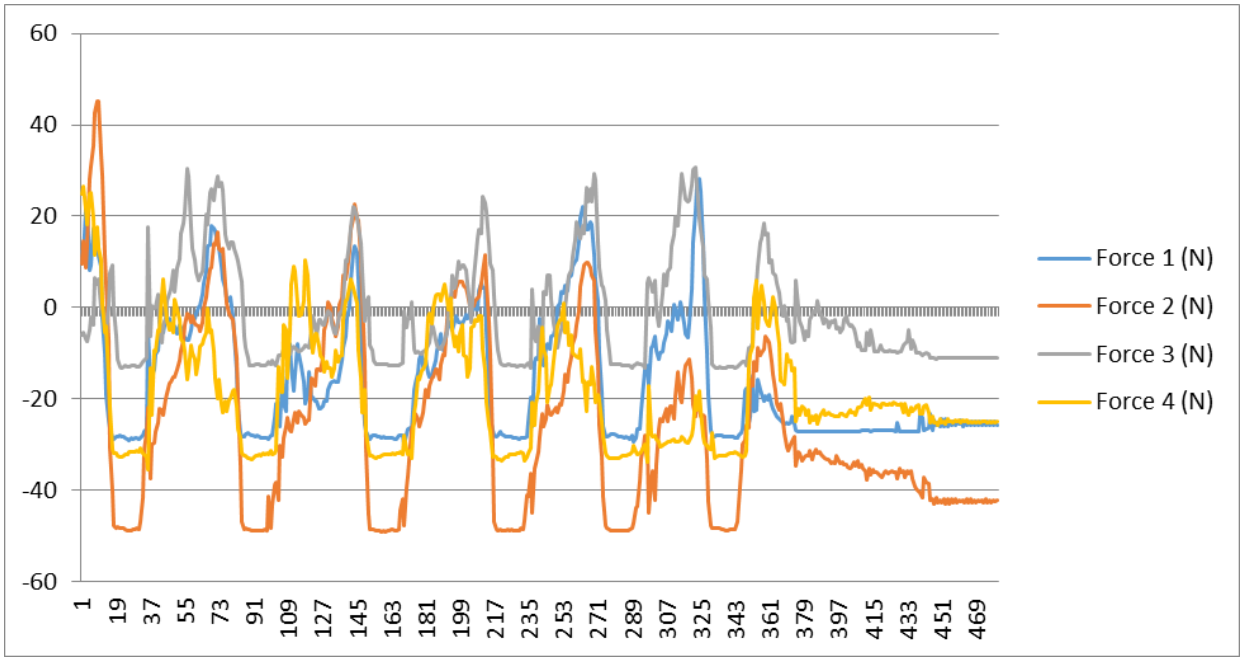

Figure 4.8.20(a): Graph of four forces of Diseased Subject XX

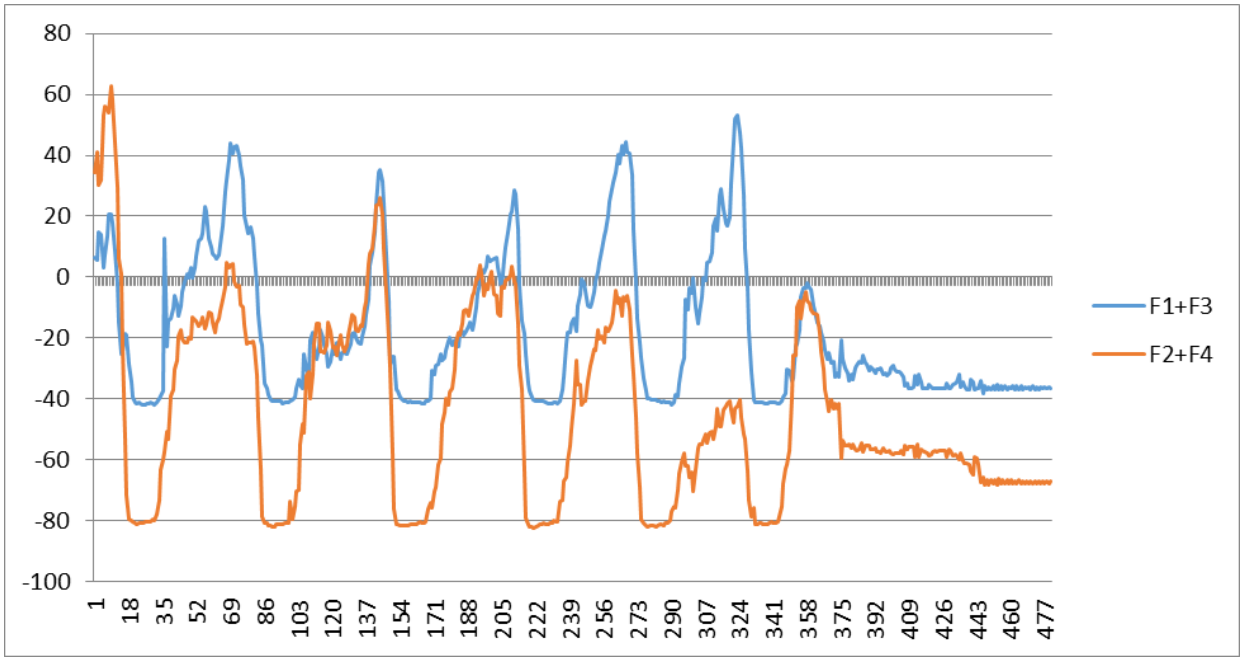

Figure 4.8.20(b): Graph of sum of two forces of Diseased Subject XX

Table 4.8.20: Data of Diseased Subject XX

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Steps	Time (sec)	Right to Left Step Length (in)	Left to Right Step Length (in)	Stride Length (inch)	Condition
20	70	50	5”3	19.5	07	28	23.2	21	44.2	osteoporosis

4.8.20 Analysis:

The increase and decreases of the forces on the graph shows the walking pattern of the patient. When the patient move forward the peaks reaches its maximum heights and when he stop the peaks decreases. Initially the F1 force reaches up to 20N, F2 up to 20N, F3 reaches 10N and F4 40N. Patient requires more upper limb force to move forward because due to increase in force the velocity decrease. Also that as the age increases the muscle force also increase due to which the velocity decrease ad the time increases. Both the mean values of F2 and F4 are not similar to the results of the normal genomic patients. Because of which we are able to predict that patient suffer problem in Right leg.

4.9 Comparative Study:

The tables of data of healthy and osteoporotic subjects are generated for comparing the results of difference between the healthy and the diseased or affected subjects. It was necessary to set the standard readings not only of the forces but also relating the conditions of waking patterns of the patients by the measurements of their age, weight, height, steps taken, time taken, step length and stride length. The differences in data of patients are present in the two tables shown.

4.9.1 Table of Healthy Subjects:

Table 4.9.1: Data of 20 elderly healthy subjects

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Step	Time (sec)	Right to left step length (in)	Left to right step length (in)	Stride Length (inch)
1	63	77	6’’7	18.5	06	16	17.2	21	38.2
2	74	66	5”6	23.4	10	19	19.5	22.2	41.7
3	74	66	5”6	22.6	07	17	21	19.5	40.5
4	83	77	5”8	25.7	10	21	22.5	24.2	46.7
5	70	74	5	32	10	19	16.2	18	34.2
6	75	57	5”3	22.3	06	20	19	23.5	42.5
7	56	75	5”10	23.7	10	17	20.2	22.5	42.7
8	55	77	5”3	30.1	10	16	19.2	21	40.2
9	87	41	4”11	18.2	10	20	17	18.5	35.5
10	85	61	5”2	24.7	10	19	16.5	17.2	33.7
11	66	56	5”6	19.8	09	18	22	20.5	42.5
12	83	77	5”8	24.6	10	17	19.2	23.5	42.7
13	56	65	5”1	27.1	09	18	17	16.5	33.5
14	70	56	5”4	21.7	10	19	20	22	42
15	67	65	5”5	23.9	10	18	16.5	18	34.5
16	62	69	5”4	26	10	17	18.2	16	34.2
17	60	62	5”2	25.2	10	18	21.5	13.5	35
18	71	67	5”6	23.7	10	19	19	17.2	36.2
19	80	59	5”7	20.4	10	21	18	22	40
20	60	64	5”10	20.2	06	16	22	23.5	45

4.9.2 Table of Diseased Subjects:

Table 4.9.2: Data of 20 elderly diseased subjects of osteoporosis

S. No.	Age (yrs)	Weight (kg)	Height (ft)	BMI	Steps	Time (sec)	Right to Left Step Length (in)	Left to Right Step Length (in)	Stride Length (inch)
01	56	48	5’’3	21.5	07	22	1	14.	28.5
02	36	50	5’’3	19.5	08	21	18	21	39
03	52	62	5’’4	23.3	07	23	18.2	21.5	39.7
04	36	52	5’’25	21.1	07	24	19	22.2	41.2
05	72	57	5’’2	23.1	05	28	17	19	36
06	64	47	5’’3	18.4	07	24	23.2	22.1	45.3
07	62	55	5”3	17.7	6	24	15	20.5	35.6
08	46	42	4”9	20	07	22	16.2	17.1	33.3
09	50	85	5’’11	26.2	08	21	19.5	22.5	42
10	60	50	5’’6	17.7	6	24	15.	20.5	35.6
11	46	42	4’’9	20	07	22	16.2	17.1	33.3
12	60	48	5’’1	20	07	24	22.2	18.5	40.7
13	30	58	5’’3	22.7	08	22	18.5	16	34.5
14	72	70	5’’5	25.7	07	27	1	17	33
15	39	55	5’’1	22.9	06	23	17	23	40
16	54	77	6	23	08	21	18	17	35
17	70	58	5’’7	20.1	09	25	17.2	19.5	36.7
18	70	61	5’’2	24.7	08	27	18.5	21.2	39.7
19	19	54	77	6	08	23	21	18	17
20	20	70	50	5”3	07	19.5	28	23.2	21

CHAPTER 5

CONCLUSION

CHAPTER 5 – CONCLUSION

5.1 Conclusion:

All the objectives which we have discussed in the chapter is able to complete properly and the prototype is designed particular manner that it performs all the tasks properly and give results in very much accurate manner. The analysis of gait pattern has been completed properly along with the data storage in the software. Secondly it has been fully accomplished that non wearable prototype has been designed for disable patients gait pattern, third the accomplishment of the human friendly walking frame has been used and then sensors are placed within it, fourth heavy wearable sensors and gait machines are being replaced by the simple model of walking frame and fifth is that all the forces F1, F2, F3 and F4 are measured properly by the help of Pasco capstone software.

This prototype will help the future patients of genomic and osteoporotic people because the team of paramedic staff and engineers will work on it and complete analysis it that how will they are able to help the future patients and save them from these problems.

5.2 Future Work:

In the future we are trying to design a 2-wheel walker with the complete analysis of new disable patients as well as the Parkinson and hemiplegic patients. We also want to perform complete analysis of their body forces so if anyone is about to infect from any kind of these problems than we will able to know before it effects the patients.

The load cell sensors of 200N are planned to be interfaced in upcoming models so that the forces of more than 100N could be calculated.

APPENDICES

```
#include "HX711.h"

// HX711.DOUT        - pin #A1
// HX711.PD_SCK      - pin #A0

HX711 scale(A1, A0);                    // parameter "gain" is ommited; the
default value 128 is used by the library

void setup() {
  Serial.begin(38400);
  Serial.println("HX711 Demo");

  Serial.println("Before setting up the scale:");
  Serial.print("read: \t\t");
  Serial.println(scale.read());                    // print a raw reading from the
ADC

  Serial.print("read average: \t\t");
  Serial.println(scale.read_average(20));       // print the average of 20
readings from the ADC

  Serial.print("get value: \t\t");
  Serial.println(scale.get_value(5));              // print the average of 5
readings from the ADC minus the tare weight (not set yet)

  Serial.print("get units: \t\t");
  Serial.println(scale.get_units(5), 1); // print the average of 5 readings from
the ADC minus tare weight (not set) divided
                                                   // by the SCALE parameter
(not set yet)
```

```
  scale.set_scale(2280.f);                    // this value is obtained by calibrating
the scale with known weights; see the README for details
  scale.tare();                               // reset the scale to 0

  Serial.println("After setting up the scale:");

  Serial.print("read: \t\t");
  Serial.println(scale.read());               // print a raw reading from the ADC

  Serial.print("read average: \t\t");
  Serial.println(scale.read_average(20));     // print the average of 20
readings from the ADC

  Serial.print("get value: \t\t");
  Serial.println(scale.get_value(5));         // print the average of 5
readings from the ADC minus the tare weight, set with tare()

  Serial.print("get units: \t\t");
  Serial.println(scale.get_units(5), 1);      // print the average of 5 readings
from the ADC minus tare weight, divided
                                              // by the SCALE parameter set
with set_scale

  Serial.println("Readings:");
}

void loop() {
  Serial.print("one reading:\t");
  Serial.print(scale.get_units(), 1);
  Serial.print("\t| average:\t");
  Serial.println(scale.get_units(10), 1);

  scale.power_down();                         // put the ADC in sleep mode
  delay(5000);
```

```
  scale.power_up();
}
```

Source code of calibration factor for load

```
#include "HX711.h"  //You must have this library in your arduino library folder

#define DOUT  3
#define CLK  2
float calibration_factor = 167772.15; //-106600 worked for my 40Kg max scale setup
void setup() {
  Serial.begin(9600);
  Serial.println("HX711 Calibration");
  Serial.println("Remove all weight from scale");
  Serial.println("After readings begin, place known weight on scale");
  Serial.println("Press a,s,d,f to increase calibration factor by 10,100,1000,10000 respectively");
  Serial.println("Press z,x,c,v to decrease calibration factor by 10,100,1000,10000 respectively");
  Serial.println("Press t for tare");
  scale.set_scale();
  scale.tare(); //Reset the scale to 0

  long zero_factor = scale.read_average(); //Get a baseline reading
  Serial.print("Zero factor: "); //This can be used to remove the need to tare the scale. Useful in permanent scale projects.
  Serial.println(zero_factor);
}

void loop() {
  scale.set_scale(calibration_factor); //Adjust to this calibration factor
```

```
  Serial.print("Reading: ");
  Serial.print(scale.get_units(), 3);
  Serial.print(" kg"); //Change this to kg and re-adjust the calibration factor
if you follow SI units like a sane person
  Serial.print(" calibration_factor: ");
  Serial.print(calibration_factor);
  Serial.println();

  if(Serial.available())
  {
    char temp = Serial.read();
    if(temp == '+' || temp == 'a')
      calibration_factor += 10;
    else if(temp == '-' || temp == 'z')
      calibration_factor -= 10;
    else if(temp == 's')
      calibration_factor += 100;
    else if(temp == 'x')
      calibration_factor -= 100;
    else if(temp == 'd')
      calibration_factor += 1000;
    else if(temp == 'c')
      calibration_factor -= 1000;
    else if(temp == 'f')
      calibration_factor += 10000;
    else if(temp == 'v')
      calibration_factor -= 10000;
    else if(temp == 't')
      scale.tare();  //Reset the scale to zero
  }
}
```

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