1) **Project Referencenumber:** 46S_BE_5201

2) **Title of the project:**A Biomechanical device for acquisition and assessment of Plantar pressure

3) **Name of the College & Department:** RNS Institute of Technology, Dept. of Electronics and Communication Engineering

4) **Name of the students & Guide(s):**


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5) **Keywords:** Plantar, Imbalance, FSR sensor, Foot pressure, Posture

6) **Introduction:**The plantar fascia is a band of tissue (fascia) that connects your heel bone to the base of toes. It supports the arch of the foot and absorbs shock when walking. Tension and stress on the fascia can cause small tears. Foot plantar pressure is the pressure field that acts between the foot and the support surface during everyday locomotion activities. Information derived from such pressure measures is important in gait and posture research for diagnosing lower limb problems, footwear design, sport biomechanics, injury prevention and other applications. Measurements of plantar pressure provide an indication of foot and ankle functions during gait and other functional activities, because the foot and ankle provide both the necessary support and flexibility for weight bearing and weight shifting while performing these activities. The major risk factors for the development of foot pain are increasing age, obesity, depression and common chronic conditions such as diabetes and osteoarthritis, while the most commonly reported foot disorders by older people are corns and calluses, nail disorders and toe deformities. Age-related fat pad atrophy, bony deformities such as hallux valgus (bunions) and hammer, claw and mallet toe, Morton's neuroma, toe nail disorders and arthritis are common foot problems in older people. Every region of foot is not equally divided in terms of plantar pressure distribution (PPD) during free standing. This paper is focusing on studying PPD on a flat plane and the results obtained from this study may contribute to biomedical researchers in designing orthotic devices. 7 healthy young adults ranging from 19 to 50 years old and weighing between 50 to 90 kg were invited for experiment purposes. Five regions of both feet were measured which were hallux, medial forefoot, lateral forefoot, lateral midfoot and heel. In community-dwelling elderly, approximately 30 percent were reported as having foot problems, and these changes may later contribute to the development of conditions leading to foot pain and impaired balance and gait performance. Several studies have shown the declination of muscle strength, range of motion, and ligament structural properties may cause abnormal foot posture in the older person. The foot posture can be categorized into three types which are normal, pronated, and supinated. Each foot type is associated with a specific locomotion pattern. The exploration of

the motion characteristics of each foot type allows building methods for automatic recognition of the foot type. Technically, the data required for such analyses are obtained through plantar pressure measurement systems.According to the structure of the foot archthere are three types of feet: normal, planus, and cavus foot. The planus foot exhibits a wholly or partly collapsed arch, whereas cavus foot characterizes with a high longitudinal arch. The proportion of the population with flat feet is about 2.2 percent among all age groups. The low arch foot is found in 10.3 percent of the population in the age range 7–14. The prevalence of cavus foot is about 10.5 percent in the age group 16–65 years.

7) **Objectives:**This project focuses on the following objectives:

   • To design a low cost user friendly platform to measure the foot pressure.

   • To determine the pressure distribution across various foot regions.

   • To identify the cause of imbalance.

   • To examine the different types of foot arches and distinguish between areas of low and high pressure.

8) **Methodology:**The foot-balancing platform can acquire pressure values from various foot sizes. The device incorporates TEN force sensors of type FSR (Force resistive sensor). Force sensors will be attached to awooden circuit board and located under the main weight-bearing areas of the foot, namely the hallux, five metatarsal heads, lateral midfoot, the lateral heel and medial heel. No sensors were placed on the medial arch area of the foot as most people exert very low/no pressure on that area due to it is arch shape. Ten inputs were multiplexed through the microcontroller then sent to host computer. All subjects were asked to place their feet on the platform, which was covered by another layer of insole on top of it to ensure comfort of the subject while standing. The acquisition and transmission circuit were connected through minimizing the size of the wire and avoiding any electrical hazard. The subject starts the trail by standing on the platform and pressure applied on the sensors gives values to the micro-controller, With the micro-controller data is processed and made to display on the LCD screen. The output of the FSR sensor is obtained in terms of resistance which is converted into N/cm^2 using a mapping function. The maximum reading obtained from analogRead(A0) is 1024, which corresponds to 5V on A0. Micro-controller data is processed and made to display on the LCD screen. The output of the FSR sensor is obtained in terms of resistance which is converted into N/cm^2 using a mapping function. The maximum reading obtained from analogRead(A0) is 1024, which corresponds to 5V on A0. A conductive pathway that can help in Based on the obtained foot pressure values, it is possible to classify the type of foot. The classification is achieved by training the model with the help of machine learning algorithms such as Rule Based Data Mining Classifier.

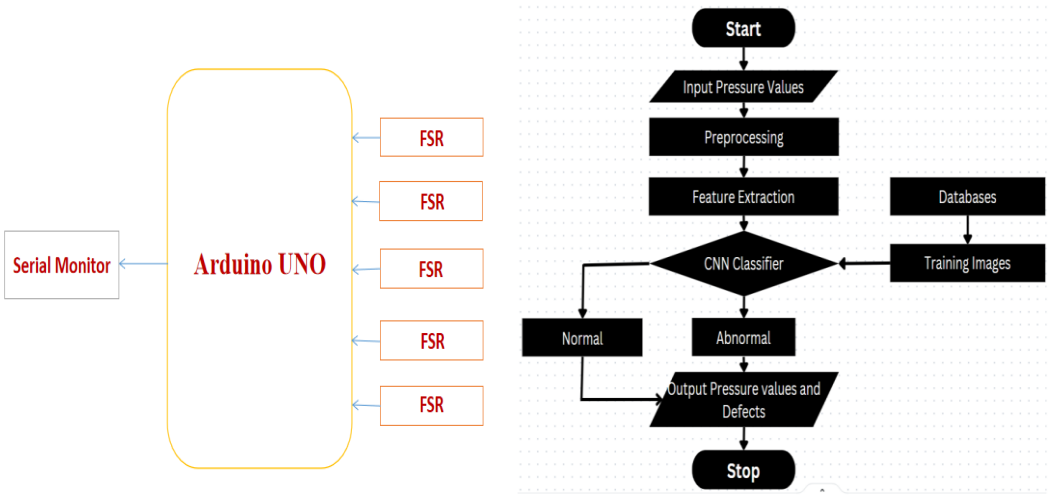


Fig.1 Block diagram of the proposed device

## 9) **Results and Conclusions:**

Table.1 Pressure values for both the legs

| | A | B | C | D | E | F | G | H | I | J | K | L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SUBJECT | | Right leg | | | | Avg.Right | | Left leg | | | | Avg.Left | FOOT TYPE |
| 2 | | S1 | S2 | S3 | S4 | S5 | N/cm^2 | S1 | S2 | S3 | S4 | S5 | N/cm^2 | |
| 3 | 1 | 13.86 | 15.004 | 13.248 | 14.678 | 15.53 | 14.464 | 14.83 | 14.887 | 15.56 | 16.77 | 16.02 | 15.6134 | NORMAL |
| 4 | 2 | 15.68 | 17.82 | 13.004 | 10.87 | 10.06 | 13.4868 | 15.58 | 17.76 | 11.0256 | 12.902 | 10.14 | 13.4815 | NORMAL |
| 5 | 3 | 14.56 | 16.798 | 14.862 | 10.45 | 16.67 | 14.668 | 14.89 | 16.787 | 14.868 | 10.39 | 13.978 | 14.1826 | NORMAL |
| 6 | 4 | 14.383 | 12.855 | 13.912 | 19.89 | 18.98 | 16.004 | 14.256 | 15.592 | 13.268 | 20.98 | 19.67 | 16.7532 | SUPINATED |
| 7 | 5 | 12.37 | 15.016 | 13.712 | 24.78 | 23.89 | 17.9536 | 15.83 | 15.025 | 19.78 | 22.67 | 23.78 | 19.417 | SUPINATED |
| 8 | 6 | 10.644 | 11.978 | 12.882 | 13.998 | 11.67 | 12.2344 | 10.432 | 11.828 | 13.002 | 14.058 | 11.45 | 12.154 | FLAT |
| 9 | 7 | 26.56 | 23.45 | 22.45 | 12.75 | 14.7 | 19.982 | 18.59 | 20.87 | 21.56 | 14.98 | 11.86 | 17.572 | PRONATED |
| 10 | 8 | 15.47 | 16.114 | 14.018 | 17.322 | 18.904 | 16.3656 | 15.72 | 16.009 | 13.904 | 17.428 | 18.912 | 16.3946 | NORMAL |
| 11 | 9 | 14.535 | 19.277 | 14.468 | 12.255 | 11.852 | 14.4774 | 14.538 | 18.265 | 12.588 | 12.144 | 12.57 | 14.021 | NORMAL |
| 12 | 10 | 19.26 | 15.88 | 12.58 | 16.68 | 17.85 | 16.45 | 18.77 | 16.8 | 13.2 | 15.58 | 18.02 | 16.474 | NORMAL |
| 13 | 11 | 15.88 | 16.64 | 16.55 | 16.89 | 17.01 | 16.594 | 17.002 | 16.998 | 11.365 | 16.98 | 17.52 | 15.973 | NORMAL |
| 14 | 12 | 13.87 | 14.008 | 13.698 | 14.588 | 13.56 | 13.9448 | 13.248 | 13.76 | 13.89 | 14.87 | 14.78 | 14.1096 | FLAT |
| 15 | 13 | 13.45 | 14.45 | 13.56 | 13.86 | 14.83 | 15.5521 | 13.56 | 14.56 | 13.86 | 14.34 | 14.83 | 14.4503 | FLAT |
| 16 | 14 | 13.22 | 14.9 | 16.21 | 24.89 | 23.56 | 15.5521 | 14.862 | 17.82 | 15.68 | 28.34 | 24.56 | 19.469 | PRONATED |
| 17 | 15 | 13.89 | 15.23 | 17.09 | 18.24 | 18.3 | 16.5 | 13.912 | 16.798 | 18.24 | 19.954 | 18.3 | 17.284 | NORMAL |
| 18 | 16 | 18.28 | 16.21 | 11.789 | 14.383 | 14.256 | 14.96 | 13.712 | 12.855 | 14.383 | 15.598 | 14.256 | 14.294 | NORMAL |
| 19 | 17 | 10.22 | 17.09 | 10.234 | 12.37 | 12.3 | 12.42 | 12.882 | 15.016 | 12.37 | 16.936 | 12.3 | 13.654 | NORMAL |
| 20 | 18 | 11.2 | 11.789 | 9.78 | 10.644 | 10.432 | 10.75 | 15.53 | 11.978 | 10.644 | 11.67 | 10.432 | 11.834 | FLAT |
| 21 | 19 | 12.9 | 10.234 | 8.56 | 23.56 | 23.45 | 13.35 | 14.018 | 16.67 | 16.49 | 21.56 | 18.59 | 16.7797 | SUPINATED |

Table.1 shows the tabular analysis for the test cases. It shows the pressure values given by the sensors, using this data graphs were plotted. In the Figure below 5-5 sets of values for both legs were taken for several people.

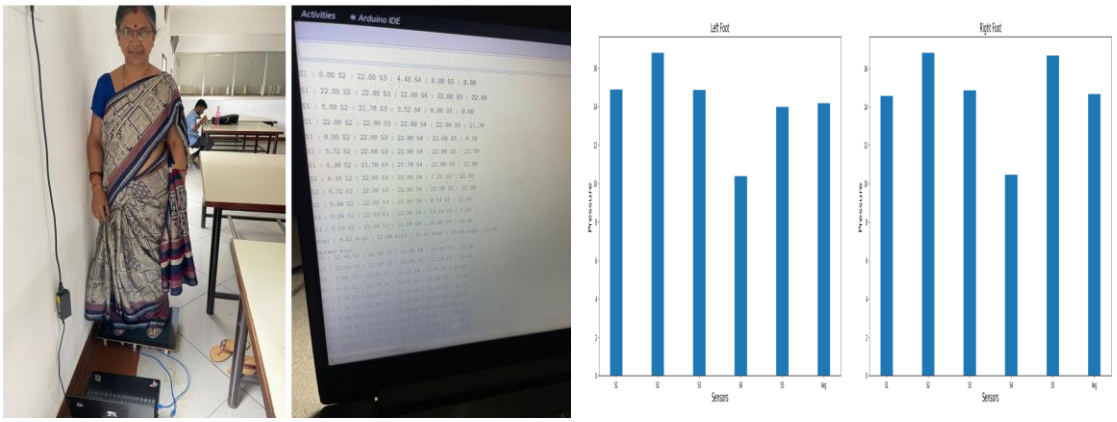


Fig.2 Subject with Normal Foot with Pressure values

Figure 3 shows subjects standing on the platform and we are observing pressure values obtained through different sensors at once. For subjects having normal foot, forefoot usually to have more pressures distributed followed by rear foot then the mid foot. Body mass will lead to an increase in pressure due to overall load, concerning impact on the fore foot, mid foot and rear foot.

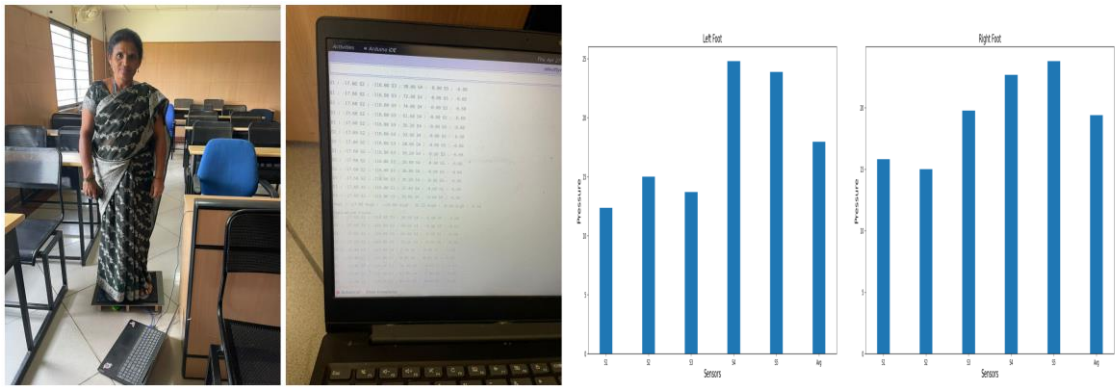


Fig.3 Subject with Supinated Foot with Pressure values

Figure 3 shows subjects standing on the platform and we are observing pressure values obtained through different sensors at once. For Subjects having Supinated foot, medial and hind foot experience more pressure towards outside direction. Same traits can be observed in graph. Graphical representation of the supinated foot pressure variations, from this graph one can observe both the legs have almost same pressure variations around lower midfoot, hindfoot and heel regions which is comparatively more than forefoot and upper midfoot regions.

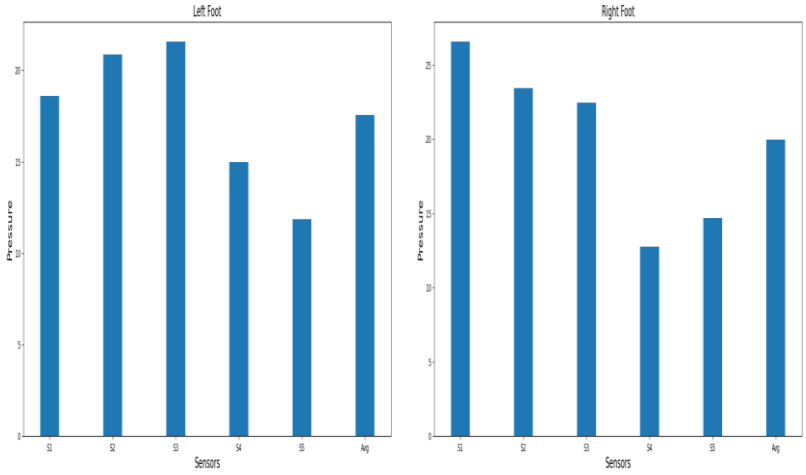


Fig.4 Pronated Foot Pressure variation

Figure 4 shows graphical representation of the pronated foot pressure variations, from this graph one can observe both the legs have almost same pressure variations around hindfoot and heel regions which is comparatively less than forefoot , upper midfoot and lower midfoot regions.

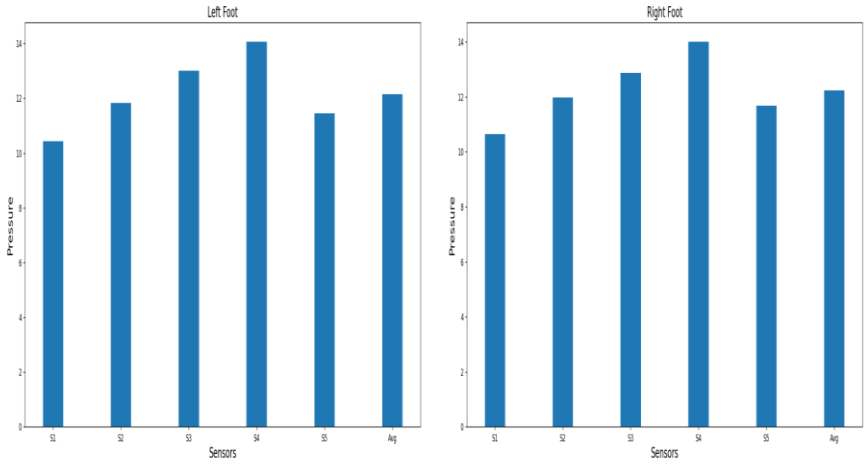


Fig.5 Flat Foot Pressure variation

Figure 5 shows graphical representation of the flat foot pressure variations, from this graph one can observe both the legs have almost same pressure variations around each regions like forefoot , upper medialfoot , lower medialfoot , hindfoot and heels regions.

## Conclusion

Measurement of plantar pressure provide an indication of foot and ankle functions during gait and other functional activities, because the foot and ankle provide both the necessary support and flexibility for weight bearing and weight shifting while performing these activities. A prototype of balancing platform, providing information about the foot pressure values is designed. The values obtained via this approach assist doctors and Physiotherapists in the development of posture correction exercises to aid in the improvement of the condition of imbalanced feet. Information derived from such pressure measures shall be used in gait and posture research for diagnosing lower limb problems, personalize footwear design, sport biomechanics, injury prevention from a physiotherapist's perspective. This system will help in a clinical setting which used by podiatrists,orthotics,prosthetics and physical therapists around the world and also to make a suitable sole to diagnose the problem claiming related to foot plantar.

## 10) Scope for future work:

• The future scope of this project is clear that various techniques capable of accurate, reliable and effectively efficient measurement of foot plantar pressure are essential to be developed.

• The same device will be helpful and useful to the giant shoe company with the interference with the low energy Bluetooth and lucrative display screen in order to instantly determine the walking/running pattern of the user.

• Once it determined, the company can build custom shoes that will increase the mobility of the use and minimize the chances of a joint issue in the future. All the foot sizes can be taken, from foot of a child to foot of an adult.

• This data can be used to increase our scope of information from only foot to knee and hips by checking what are the different regions experiencing more or less pressure so that we can include different aspects of neuro engineering.

• Efficiency of this project can be increased by including the concept of thermal imaging with AI.