Vol 7 Issue 2 March 2017

ISSN No : 2230-7850

International Multidisciplinary Research Journal

# Indian Streams Research Journal

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**RNI MAHMUL/2011/38595** **ISSN No.2230-7850**

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INDIAN STREAMS RESEARCH JOURNAL

ISSN: 2230-7850
IMPACT FACTOR : 5.1651(UIF)
VOLUME - 7 | ISSUE - 2 | MARCH - 2017

# A STUDY OF STATIC FOOT PRESSURE MEASUREMENT IN DIABETIC PATIENTS

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**ABSTRACT**

*Foot ulceration is a preventable long-term complication of diabetes. Diabetic foot complications cause huge economic burden to the society, The only way to solve this problem is to prevent it with preventive measures. Hence it is important to diagnose foot problems at an early stage of injury, prevention risk management and general well being. One approach to measure the foot health, widely used is examining foot plantar pressure characteristics. It is therefore important that accurate and reliable and affordable measurement system developed.*

*In the present study, plantar pressures in a group of 110 Indian patients with diabetes, with or without neuropathy and foot ulcers were taken. The aim was to develop low cost foot pressure scanner and check the reliability and validity of the tool developed which will help to prevent the further complications of foot ulcers like amputation and prolonged hospitalization.*

*There are differences in static foot pressure in different study groups such as diabetic patients, patients with diabetic peripheral neuropathy, patients with foot ulcers and non diabetics were significant at P<.0,01 level of significance, hence the developed machine differentiated the diseased group efficiently.Hence tool developed was valid.The Reliability of the tool was checked by Test Retest method. The readings were consistent at each point of the foot, p0, p1 and p2.*

*Based on the results of the present study it is concluded that the present developed machine can perform accurate and repeatable digital representation of foot pressure which also can be successfully used in footwear development to prepare offloaded shoes. It is novel method to monitor foot health proactively in an effort to reduce and prevent diabetic foot complications.*

**KEYWORDS:** *prevention risk management , prolonged hospitalization , Static Foot Pressure Measurement , Diabetic Patients.*

## INTRODUCTION :

In the recent years, the plantar pressure has widely been accepted as a vital biomechanical parameter to evaluate human walking. The distribution and magnitude of plantar pressure can provide useful information to diagnose the various foot disorders. Plantar pressure measurements during standing, walking or other activities can demonstrate the path mechanics of the abnormal foot and yield objective measures to track disease progression. A callus formation on the plantar surface of the foot can elevate the plantar pressure up to 30%. Bony abnormalities that are observable on radiological examination may offer the possibility of predicting

some of the variance in plantar pressure on the basis of structural factors alone. Several studies on foot biomechanics have reported that plantar pressure variations are useful to determine the abnormal gait. Pathologic gait can be broadly divided on the basic etiology, into either neuromuscular or musculoskeletal. Many research groups realized the potential of pressure measurement technology for the diagnosis and treatment of various foot disorders. Plantar pressure studies on the rheumatoid foot have also been undertaken by a number of research groups.

Plantar pressure studies in patients with diabetic neuropathy have indicated a relationship between excessive localized pressure and ulceration. These patients are at risk of recurrent ulceration and impaired pain because of increased pressures under the metatarsal heads. Earlier studies have described the value of plantar pressure analysis for the understanding of diabetic foot function as well as of the possibilities for therapeutic intervention. Researchers have investigated therapeutic footwear for the diabetic foot, especially various designs of rocker bottom shoes. Numerous studies have proven the usefulness of pressure distribution measurements for the prescription of therapeutic footwear. The damage to tissue in the foot not only depends upon the peak pressure, but it has a great dependence on the type of physical activities carried out and the type of footwear used. The effect of variation of the foot pressure measured with different gait parameters is not fully understood. Therefore, there is a need to study normal and pathological subjects to know the exact values of peak pressures on the plantar surface of the foot. The diversity of commercially available systems to measure the plantar pressure has resulted in different measuring systems producing different results and not affordable to the community.No proven pressure threshold for tissue damage exists, which could be true for all systems.

Diabetic foot ulceration is a preventable long-term complication of diabetes. Diabetic foot complications cause huge economic burden to the society, the only way to solve this problem is to prevent it with preventive measures. Hence it is important to diagnose foot problems at an early stage of injury, prevention risk management and general well being. One approach to measure the foot health, widely used is examining foot plantar pressure characteristics. It is therefore important that accurate and reliable measurement system developed.

In the present study, plantar pressures in a group of 110 Indian patients with diabetes, with or without neuropathy and foot ulcerswere taken. The aim was to develop low cost foot pressure scanner and check the reliability of the tool developed which will help to prevent the further complications of foot ulcers like amputation of leg and prolonged hospitalization.

## MATERIAL AND METHODS

Since the main objective was to develop a low cost foot pressure scanner and check the reliability and validity of the tool for affordable price without going to the hospital, the components used for the scanner were force sensors with capacity of 0 to 150 Kilo Pascal with 0.5” sensing area, Arm Processors, data reader card with digital display, micro controller and Micro cellular rubber. These were assembled in collaboration with Biomedical Engineering department, of KLES Engineering College, Belgavi, Magnum Technology, Belgavi.Biomedical Engineering Department to come up with the final version.

The Cross sectional, analytical study was carried out in health care setting of the two corporate hospitals of Belgaum city, Karnataka, India. The study was undertaken on 110 subjects’ out of this, 30 non diabetics, 30 diabetics, 19 diabetic with peripheral neuropathy and 31 with diabetic foot ulcer.

The subjects were asked to stand on the foot pressure scanner three times and the readings were noted by the same rater on the same machine.

The Plantar foot pressure was measured in Kilo Pascal Units on P0-first metatarsal, P1- second metatarsal, P2- fifth metatarsal. Reliability of the tool was checked by test retest method and checked the consistency of the tool.

## RESULTS

**Table 1: Distribution of Study, Subjects by Age and Gender, (n=110)**

| Age in Years | Nor mal | % | Diabetes Mellitus | % | Diabetes Peripheral Neuropathy | % | Foot Ulcer | % | Total | % |
|---|---|---|---|---|---|---|---|---|---|---|
| Male | | | | | | | | | | |
| **<50** | 4 | 26.67 | 3 | 30.00 | 3 | 23.08 | 5 | 21.74 | 15 | 24.59 |
| **50-59** | 11 | 73.33 | 6 | 60.00 | 5 | 38.46 | 9 | 39.13 | 31 | 50.82 |
| **60+** | 0 | 0.00 | 1 | 10.00 | 5 | 38.46 | 9 | 39.13 | 15 | 24.59 |
| **Total** | 15 | 100.00 | 10 | 100.00 | 13 | 100.00 | 23 | 100.00 | 61 | 100.00 |
| **Female** | | | | | | | | | | |
| **<50** | 7 | 46.67 | 2 | 10.00 | 1 | 16.67 | 3 | 37.50 | 13 | 26.53 |
| **50-59** | 6 | 40.00 | 15 | 75.00 | 2 | 33.33 | 2 | 25.00 | 25 | 51.02 |
| **60+** | 2 | 13.33 | 3 | 15.00 | 3 | 50.00 | 3 | 37.50 | 11 | 22.45 |
| **Total** | 15 | 100.00 | 20 | 100.00 | 6 | 100.00 | 8 | 100.00 | 49 | 100.00 |
| **Total** | | | | | | | | | | |
| **<50** | 11 | 36.67 | 5 | 16.67 | 4 | 21.05 | 8 | 25.81 | 28 | 25.45 |
| **50-59** | 17 | 56.67 | 21 | 70.00 | 7 | 36.84 | 11 | 35.48 | 56 | 50.91 |
| **60+** | 2 | 6.67 | 4 | 13.33 | 8 | 42.11 | 12 | 38.71 | 26 | 23.64 |
| **Grand Total** | 30 | 100.00 | 30 | 100.00 | 19 | 100.00 | 31 | 100.00 | 110 | 100.00 |

Table 1 depicts male 26.6% below the age of 50 years among 73.3% below the age of 59 years participated in the study among normal group and no subject was above 60 years among them.

**Female**

46.6% below the age of 50 years, 40.0% below the age of 59 years. 13.33% were above 60 years of age

It reveals that the male and female gender subjects participated in the study among diabetes mellitus group respectively.

**Male**

Below 50 years of age 30%, Below 59 years of age 60%, Above 60 years of age 10%

**Female**

Below 50 years of age 10%, Below 59 years of age 75%, Above 60 years of age 15%

It shows that, the male and female gender subjects participated in the study group among diabetes Peripheral Neuropathy respectively.

**Male**

below 50 years 23.8%, Below 59 years 38.4%, above 60 years 38.4%

**Female**

below 50 years 16.6%, Below 59 years 33.3 %, above 60 years 58%

Reveals that, the Male & Female gender participated in the study among the subjects with Foot Ulcer.

**Male**

below the age of 50 years 21.74%, Below the age of 59 years 39.15%, Above 60 years of age 39.13%

**Female**

below the age of 50 years 37.50%, Below the age of 59 years 25%, Above 60 years of age 37.50%

**Table2: Static Foot Pressure in study groups n=110**

| Final Diagnosis | Reading | | | | | | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| | Groups | 1st | | 2nd | | 3rd | | | |
| Normal (n=30) | Statistics | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| | P0 | 137.27 | 7.037 | 136.47 | 7.045 | 134.77 | 7.162 | 136.17 | 7.079 |
| | P1 | 126.2 | 8.151 | 125.07 | 7.847 | 124.13 | 8.207 | 125.13 | 8.024 |
| | P2 | 113.1 | 10.179 | 110.8 | 10.874 | 109.9 | 10.36 | 111.27 | 10.445 |
| Diabetes Mellitus (n=30) | P0 | 139.1 | 5.689 | 137.5 | 5.488 | 135.83 | 5.253 | 137.48 | 5.581 |
| | P1 | 133.77 | 6.611 | 130.07 | 9.989 | 128.37 | 9.257 | 130.73 | 8.934 |
| | P2 | 122.2 | 15.399 | 122.07 | 15.371 | 119.17 | 16.526 | 121.14 | 15.66 |
| Diabetes Peripheral Neuropathy (n=19) | P0 | 131.95 | 12.616 | 131.89 | 13.383 | 132.37 | 13.471 | 132.07 | 12.927 |
| | P1 | 100.16 | 27.124 | 99.16 | 27.009 | 99.32 | 27.244 | 99.54 | 26.641 |
| | P2 | 109.68 | 19.734 | 109.79 | 19.355 | 109.84 | 19.942 | 109.77 | 19.324 |
| Foot Ulcer (n=31) | P0 | 133.87 | 19.578 | 133.71 | 19.463 | 133.45 | 19.134 | 133.68 | 19.182 |
| | P1 | 110.35 | 29.53 | 109.9 | 29.514 | 109.71 | 29.178 | 109.99 | 29.088 |
| | P2 | 114.68 | 27.366 | 115.03 | 27.079 | 114.68 | 26.759 | 114.8 | 26.774 |
| Total (n=110) | P0 | 135.89 | 12.681 | 135.18 | 12.629 | 134.27 | 12.381 | 135.12 | 12.543 |
| | P1 | 119.3 | 23.412 | 117.68 | 23.182 | 116.94 | 22.733 | 117.97 | 23.062 |
| | P2 | 115.44 | 19.522 | 114.89 | 19.528 | 113.76 | 19.469 | 114.7 | 19.459 |

Table 2revealed that, the static foot pressure shows similar reading at 0.5 level of significance.Hence, it is reliable, whereas there were difference in static pressure of foot in different study groups such as diabetic patients, diabetic with peripheral neuropathy, foot ulcer and normal group at $p<0.01$ level of significance. Hence, the tool is valid.

## DISCUSSION

Traditionally foot pressure measurement is performed in the specialized settings such as laboratory, hospitals and other clinical premises but this developed machine is portable and affordable to the community having limited cabling, low cost, linear with low hysteresis.

Several studies have been conducted to develop the foot pressure scanner with high technological advancement which are expensive and not affordable to a common man. This developed machine is made out of force sensors with capacity of 0 to 150 Kilo Pascal with 0.5" sensing area, Arm Processors, data reader card with digital display, micro controller and Micro cellular rubber.

With comparative to the machines already available in the market this developed machine gives the required reading for the measuring of foot pressure accurately which also serves the purpose of machine made for.

There are differences in static foot pressure in different study groups such as diabetic patients, patients with diabetic peripheral neuropathy, patients with foot ulcers and non diabetics were significantly different at P<.0,01 level of significance, hence the developed machine differentiated the diseased group efficiently.

In the present study at P0:first metatarsal, P1:second metatarsal and P2: third metatarsal, the readings taken are consistent and reliable at 0.05 significant levels by Test Retest method of finding reliability.

## CONCLUSION

Based on the results of the present study, it is concluded that the present developed machine can perform accurate and repeatable digital representation of foot pressure which also can be successfully used in footwear development to prepare offloaded shoes. It is novel method to monitor foot health proactively in an effort to reduce and prevent diabetic foot complications.

## ACKNOWLEDGEMENT

Authors are most grateful to all the patients who participated in this study which facilitated the research work effectively.

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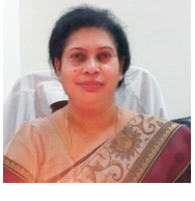

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