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A STUDY OF DYNAMIC FOOT PRESSURE MEASUREMENT IN DIABETIC PATIENTS

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ABSTRACT

Diabetic foot ulcer is considered as a major source of morbidity and a leading cause of hospitalization in patients with diabetes. It is estimated that approximately 20% of hospital admissions among patients with diabetes mellitus are the result of diabetic foot ulcer. It can lead to infection, gangrene, amputation, and even death if necessary care is not provided. On the other hand, once diabetic foot ulcer has developed, there is an increased risk of ulcer progression that may ultimately lead to amputation. Overall, the rate of lower limb amputation in patients with diabetes mellitus is 15 times higher than patients without diabetes. The development of miniature, lightweight, and energy efficient circuit solutions for healthcare sensor applications is an increasingly important research focus given the rapid technological advances in healthcare monitoring equipment. Based on this research it is clear that techniques capable of accurately and efficiently measuring foot pressure are crucial to further developments.

In the present study, plantar pressures in a group of 110 Indian patients with diabetes, with or without neuropathy and foot ulcers are 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 of the patients.

There are differences in dynamic 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.Reliability of the tool was checked by test retest method and checked the consistency of the tool.

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- *Foot pressure scanner, Reliability, Dynamic foot pressure .*

INTRODUCTION :

Diabetes mellitus is one of the majorproblems in global public health today.The threat has increased dramatically over the past 2 decades. According to epidemiological studies, the number of patients with diabetes mellitus increased from about 30 million cases in 1985, 177 million in 2000, 285 million

in 2010, and estimated if the situation continues, more than 360 million people by 2030 will have diabetes mellitus.

Patients with diabetes mellitus are prone to have multiple complications, but one of the complication, which is prominent is foot ulcer. Itis a common complication which has shown an increasing trend over previous decades. In total, it is estimated that 15% of patients with diabetes will suffer from diabetic foot ulcer during their lifetime. Although accurate figures are difficult to obtain for the prevalence of diabetic foot ulcer, the prevalence of this complication ranges from 4%-27%.

Diabetic foot ulcer is considered as a major source of morbidity and a leading cause of hospitalization in patients with diabetes.It is estimated that approximately 20% of hospital admissions among patients with diabetes mellitus are the result of diabetic foot ulcer.Itcan lead to infection, gangrene, amputation, and even death if necessary care is not provided. On the other hand, once diabetic foot ulcer has developed, there is an increased risk of ulcer progression that may ultimately lead to amputation. Overall, the rate of lower limb amputation in patients with diabetes mellitus is 15 times higher than patients without diabetes. It is estimated that approximately 50%-70% of all lower limb amputations are due to diabetic foot ulcer. In addition, it is reported that every 30 s one leg is amputated due to diabetic foot ulcer in worldwide. Furthermore, diabetic foot ulcer is responsible for substantial emotional and physical distress as well as productivity and financial losses that lower the quality of life.

The development of miniature, lightweight, and energy efficient circuit solutions for healthcare sensor applications is an increasingly important research focus given the rapid technological advances in healthcare monitoring equipment. One area that has attracted considerable attention by researchers in biomedical and sport related applications is the analysis of foot plantar pressure distributions to reveal the interface pressure between the foot plantar surface and the shoe sole. Based on this research it is clear that techniques capable of accurately and efficiently measuring foot pressure are crucial to further developments.

The plantar pressure systems available on the market arewith high technology and not affordable for common man.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 of the patients by providing them offloaded shoes.

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 KLE's Engineering College, Belgavi and 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 and made to walk on the treadmill with 0.8 mph and ten times 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. And the validity was checked by taking foot pressures on different subjects such as diabetic patients, diabetic with peripheral neuropathy, foot ulcer and non-diabetic groups.

Results

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

Age in Years	Normal	%	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%

This study revealed that, the dynamic foot pressure shows similar reading at 0.5 level of significance. Hence, it is reliable, whereas there were difference in dynamic 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 were 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.

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