ASSESSMENT OF FOOT PRESSURE DISTRIBUTION IN JUVENILE DIABETES MELLITUS

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Abstract

Background: As the incidence of type 1 diabetes continues to rise, the burden of microvascular complications will also increase and negatively influence the prognosis of young people with the disease. Diabetic vascular complications are often asymptomatic during their early stages, and once symptoms develop, there is little to be done to cure them. Therefore, it is essential that screening for foot complications in young children. The purpose of this study was to investigate foot pressure distribution in diabetic children compared to normal children. **Methods:** Fifty five children contributed in this study: thirty normal children as control group (A) and twenty five diabetic children as study group (B) their ages ranged between ten and fifteen years with normal body mass index and they were able to follow instructions and understand commands given to them during the testing procedures. None of them had flat foot nor suffer from musculoskeletal deformities and/or neuromuscular disorders; they had neither visual, auditory defects nor autistic features. The planter pressure distribution of the diabetic and normal children was measured by footscan pressure plate during static and walking in each subject during normal walking speed. Maximum pressure values in right and left sides were compared in both groups in static and dynamic situations. **Results**: data analyzed by “Unpaired t test" to compare Maximum pressure at static and dynamic situations between both groups. The results of current study revealed that there was a statistically significant difference in maximum pressure in both right and left sides between the two groups in both static and dynamic assessment and this significant increase in group (B) in compared to group (A). **Conclusion:** foot pressure distribution is affected in children with type 1 diabetes mellitus.

Keywords: diabetes mellitus, planter pressure, pressure plate.

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Introduction

Diabetes mellitus is a group of metabolic disorders which results from a failure of endocrine system to control blood glucose levels within normal limits that characterized by hyperglycemia, and disorders of carbohydrates, fats and protein metabolism, with symptoms of polyuria, polyphagia, polydipsia, and loss of weight [1].

Several pathogenic processes are involved in the development of diabetes. These range from autoimmune destruction of the pancreatic b-cells with consequent insulin deficiency to abnormalities that result in resistance to insulin action [2]**.**

Most cases of DM falls into two broad eitopathogenic categories. The first category is termed type (1) diabetes , in which the cause is an absolute deficiency of insulin secretion. The other category is termed type(2) diabetes, the causes are combination of resistance to insulin action and inadequate compensatory insulin secretory response. In this latter group the degree of hyperglycemia is sufficient to cause pathogenic and functional responses in various target tissues. Type (1) DM can occur at any age and is characterized by the marked and progressive inability of the pancreas to secrete insulin because of autoimmune destruction of the beta cells. It commonly occurs in children. The distinguish characteristic of a patient with type (1) is that they are dependent on exogenous insulin. [3]

. The average annual increase in the incidence in children under 15 years old is 3.4% with steepest rise in those under 5 years old with an equal incidence in both sexes and an increased prevalence in white population [4]

Persistent and poorly controlled hyperglycemia causes neuropathic and vascular abnormalities that lead to foot deformities and skin breakdown [5].

Posture ability is a neurological control activity dependence by nervous system that provides the optimal spatial framework for body adjustment. The input data for posture adjustment are received by the brain through various peripheral channels, processed and send to different systems for deployment. High plantar pressure generates posture abnormalities [6].

The human foot plays an important role in maintaining the biomechanical function of the lower extremities which includes provision of balance and stabilization of the body during gait [7].

A foot scan is the method by which we examine the biomechanics of the feet. It provides a dynamic weight-bearing computerized assessment of the biomechanics of a person's feet. The system measures the weight distribution at all contact points along the bottom surface of the foot. It measures and analyses the way a person walks because how we walk can cause potential problems with the rest of the body[8].

Appropriate treatment and early detection with methods such as plantar pressure distribution measurement might prevent the vast majority of diabetic foot complications that result in amputation do being with formation of foot ulcers[9].

Abnormally high plantar pressure in people with sensory deficits of the lower limbs has been linked with ulcer foot complications [10]. Reduction of peak plantar pressure on the forefoot during walking has become aprimary focus of prevention and treatment of this condition[11].

Several previously published studies illustrated how physical therapist has utilized plantar pressure distribution as a quantitative measurement for the assessments and management of lower extremity and foot disorders associated with the neurological , and musculoskeletal systems [12], Plantar pressure monitoring systems have been used by researchers in gait analysis to enhance footwear or therapeutic orthotics designs [13].

So, the aim of this study was to investigate changes in foot pressure distribution in diabetic children compared to normal children.

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Subject, materials and methods

Subjects:

Study design: a cross sectional study.

Subjects :

Fifty five children their ages ranged between ten to fifteen years contributed in this study: thirty normal children as control group (A) and twenty five diabetic children as study group (B) who were diabetic for at least five to seven years.they were enrolled in this study from April 2017 to March 2018. The participants were included when they had normal body mass index (according to the scale for normal boys and girls) and they were able to follow instructions and understand commands given to them during the testing procedure to produce accurate and reliable measurement. While, they were excluded when they had flat foot or suffered from musculoskeletal deformities and/or neuromuscular disorders, they didn't have visual or auditory defects and none of them were obese or underweight.

This study was approved by the research ethics committee of Physical Therapy College, Cairo University.

All the parents of the participants were given their informed (verbal or written) consent form to have their children participate in the study.

Materials

Hanson professional scale was used to measure weight and height to calculate body mass index, and exclude the obese or underweight children.

Children's plantar pressure was measured by Footscan pressure plate. Hafer,et al., [14] indicated the reliability of plantar pressure platforms in asymptomatic healthy group of subjects. They also indicated that for most parameters, reliable data can be achieved with as few as 3 walking trials.

The pressure plate contained sensors, which converted the mechanical pressure of the foot into electrical signals routed to the computer system. The software calculated the pressure values according to the pressure imposed on the plate .Also it used specified color to display the pressures acting on the planter surface of the foot in various preset colors .The red and purple colors denoted graphically the highest pressure, while green, blue and black colors represented the lowest pressure values.

Measurement procedures

Measurement evaluation procedures were performed for all normal and diabetic children.The Childs' personal data (name, weight and height) had been collected and then stored on the computer in their specific folder.

The system had been calibrated, then had been activated and ready to record the pressure when the child had been asked to stand or walk over the pressure plate.

Static:

For static pressure record; the children were asked to stand over the platform on its active area with bare foot , looking forward and stay in this position for few seconds . The pressure data were collected and transferred directly to a laptop computer where it was saved for later analysis.

Dynamic:

For dynamic pressure record; the subject was asked to walk with bare foot in walkway with normal free walking speed while looking straight ahead and step over the platform, then continued walking to the other end of the walkway, for each subject, a minimum of three passes per foot was obtained. As they were younger subjects, obtaining the minimum number of passes required collection of a greater number of passes to ensure that unsatisfactory trails (i.e. child running, shuffling, hopping, etc.) were excluded.

For the reliability of the measurement the subject walked across the platform three to five times to be familiarized with the walking over platform. If a subject obviously aimed at the platform and altered the gait pattern to ensure full contact, the trail was not included for further analysis.After completion of the trials, the measurements were saved in the subject's folder for analysis.

Data analysis

Prior to final analysis, data were screened for normality assumption, homogeneity of variance, and presence of extreme scores. This exploration was done as a pre-requisite for parametric calculations of the analysis of difference. Descriptive analysis was obtained using histograms for each variable.

"Unpaired t test" was conducted to compare Maximum pressure at static and dynamic situations between both groups, Means and standard deviations were calculated for both groups. Statistical analysis was conducted using SPSS for windows, version 23 (SPSS, Inc., Chicago, IL)..

Results

General Characteristics:

The current study was conducted on fifty five participants. They were assigned into two groups. Group (A) consisted of thirty normal children with mean age, body mass and height values of 12±0.94 years, 48.33±6.7 kg and 155.63±7.61 cm. Group (B) consisted of twenty five diabetic children with mean age, body mass and height values of 12.04±0.97 years, 47.76±6.94 kg and 153.2±7.71 cm respectively. As indicated by the independent t test, there were no significant differences (p>0.05) in the mean values of age, body mass and height between both tested groups table (1).

Table (1): Demographic characteristics of participants in both groups.

Group / Items	Group A	Group B	Comparison		S
	Mean ± SD	**Mean ± SD**	**t-value**	**P-value**	
Age (years)	12±0.94	12.04±0.97	-0.154	0.878	NS
Body mass (Kg)	48.33±6.7	47.76±6.94	0.311	0.757	NS
Height (m)	155.63±7.61	153.2±7.71	1.17	0.246	NS

*SD: standard deviation, P: probability, S: significance, NS: non-significant.

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A. Maximum pressure at static situation:-

(1). Comparison of the right and left side Values between both groups:

As revealed from **table (2),**there was a statistically significant difference in the maximum pressure at static situation in both right and left sides between both groups of the study and this significant increase in favor to group (B) in compared to group (A) (t=4.406, 4.928 respectively). Fig. (1) shows the comparison of maximum pressure at static situation between both groups of the study.

Table (2): **Comparison mean values of maximum pressure of both right and left sides at static situation between normal and diabetic groups of the study***:*

Group / Items	Maximum pressure at static situation			
	Right side		**Left side**	
	Group (A)	**Group (B)**	**Group (A)**	**Group (B)**
$\bar{X}$	**734.92**	**911.06**	**700.4**	**852.46**
±SD	**±79.02**	**±186.17**	**±37.84**	**±150.13**
MD	**176.14**		**152.06**	
T-Value	**4.406**		**4.928**	
P-Value	**0.0001***		**0.0001***	
Level of significance	**S**		**S**	

N. B
X =Mean,
±SD=Standard deviation,
MD=Mean difference,
P-Value=Probability level,
N.S= Non-significance,
S= Significant.

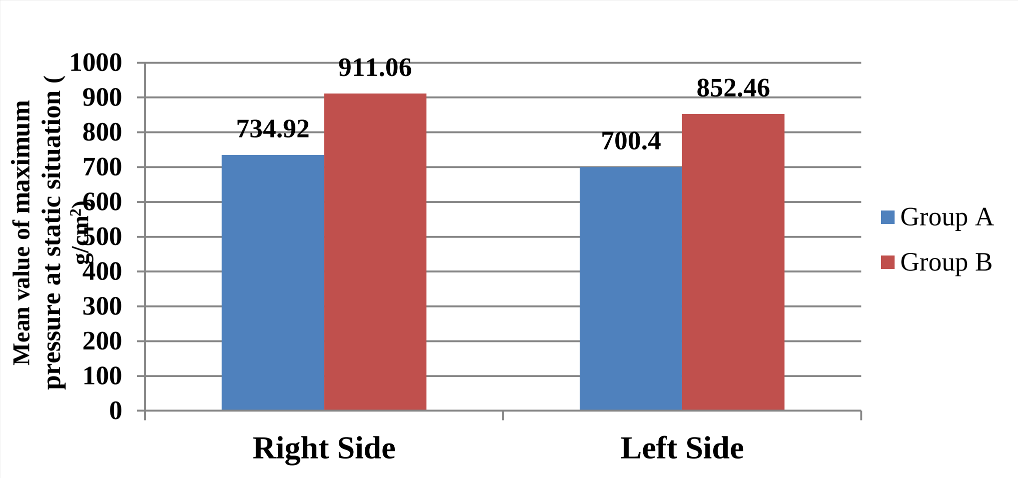

Fig. (1): A comparison of maximum pressure at right and left side in static situation between both groups of the study.

B. Maximum pressure at dynamic situation: -

(1). Comparison of the right and left side Values between both groups:

Table (3), shows that there was a statistically significant difference in the maximum pressure at dynamic situation in both right and left sides between both groups of the study and this significant increase in favor to group (B) in compared to group (A) (t=4.518, 3.684 respectively). Fig. (2), shows the comparison of maximum pressure at dynamic situation between both groups of the study.

Table (3): **Comparative analysis of maximum pressure at dynamic situation between two groups of the study***:*

Group / Items	Maximum Pressure At Dynamic Situation			
	Right side		Left side	
	Group (A)	Group (B)	Group (A)	Group (B)
$\bar{X}$	1555.56	1861.93	1613.64	1884.53
±SD	±39.11	±336.66	±150.58	±340.52
MD	306.37		270.89	
T-Value	4.518		3.684	
P-Value	0.0001*		0.001*	
Level of significance	S		S	

N. B

$\bar{X}$ =Mean, ±SD=Standard deviation,
MD=Mean difference, P-Value=Probability level,
N.S= Non-significance, S= Significant.

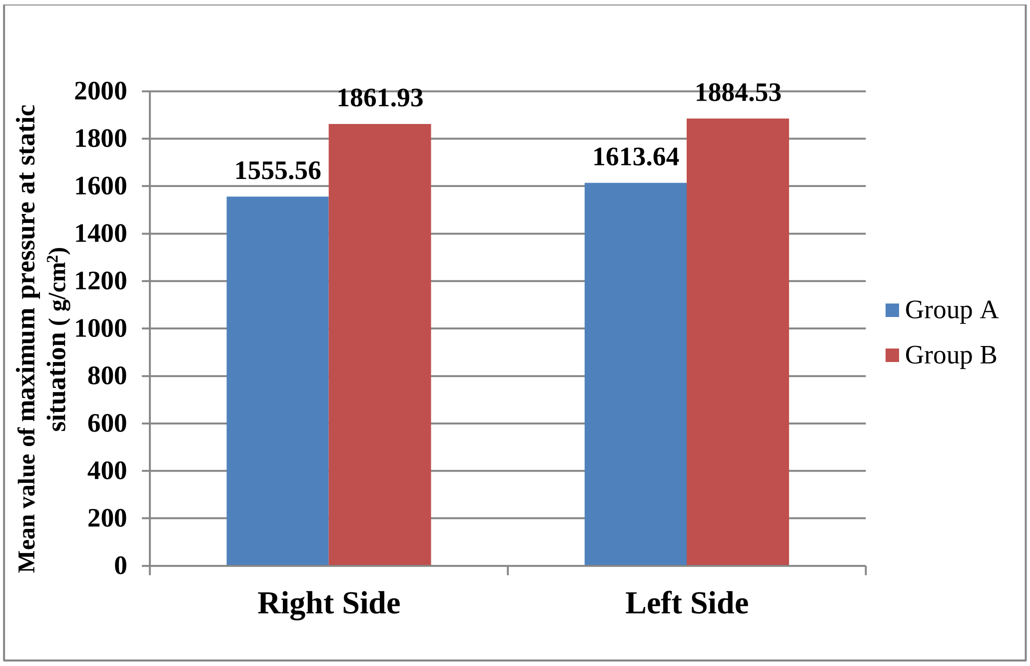

Fig. (2): A comparison of maximum pressure at right and left side in dynamic situation between both groups of the study.

Discussion

This study was conducted to assess changes in foot pressure distribution in diabetic children compared to normal children. Results of this study found that there is an increase in the foot pressure in diabetic children which could be attributed to sensory deficits according to peripheral neuropathy. This comes in agreement with **Caselli A. et al**.[15], who reported that both forefoot and rearfoot peak plantar pressures increase with increasing degrees of nerve damage, but the forefoot / rearfoot peak plantar ratio is increased only in advanced peripheral neuropathy. Nelson et al [16] demonstrated that there is a high prevalence of peripheral neuropathy (57%) in children and adolescents with type 1 diabetes mellitus for greater than 5 years. dorsal sural nerve conduction velocity (which have value to determine neuropathy in the early stages in children with diabetes) is slower in diabetic children than in normal children[17]. The increase in prevalence of delayed nerve conduction velocities occurs during the middle teen years of diabetic children [18].

Diabetic neuropathy is defined by a clinical or subclinical disorder, without any additional causes of peripheral neuropathy other than diabetes, and can be either somatic or autonomic [19] **.**Chronic distal symmetric polyneuropathy is the most common form of diabetic neuropathy and is characterized by symmetric damage of peripheral small sensory and large motor nerve fibers[20]**.**

In epidemiological studies involving young people with T1D, the percentage of subjects affected by peripheral diabetic neuropathy ranged from 9 to 58% [19], with variations depending on the different cohorts of patients studied, different testing modalities and different criteria and cut off values.

The foot is a highly unique and flexible structure which is required to perform very diverse functions, particularly during weight-bearing activities [21]. Whilst the structurally normal foot can adequately perform these tasks, deviations from its normal posture can place the foot under excessive stress, often leading to discomfort or pain [22]**.**

The plantar pressure measurements during standing, walking and running can demonstrate the pathomechanics of foot disorders and give objective measures to track disease progression. Several studies in foot biomechanics have reported the plantar pressure variation is useful to determine pathological gait. Pathological gait can be divided on the basic etiology either neuromuscular or musculoskeletal [23].

The result of this study is confirmed by **Merrolli and Uccioli** [24] who founded that Prolonged duration of the gait cycle and shear stresses characterize the plantar pressure pattern of diabetic neuropathic patients,but this study was on adult subjects.

According to the results of present study, there is a significant difference in foot pressure in diabetic children.

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