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Original article

Relationship of planter pressure and glycemic control in type 2 diabetic patients with and without neuropathy

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ABSTRACT

Introduction: Foot disease is a common complication of type 2 diabetes that can have tragic consequences. Abnormal plantar pressures are considered to play a major role in the pathologies of neuropathic ulcers in the diabetic foot.
Aim: To examine Relationship of Planter Pressure and Glycemic Control in Type 2 Diabetic Patients with and without Neuropathy.
Materials and methods: The study was conducted on 50 type 2 diabetic patients and 30 healthy volunteers. BMI calculation, disease duration, Hemoglobin A1c and presence of neuropathy (by history, foot examination and DN4 questionnaire) were recorded. Plantar pressure was recorded for all patients using the Mat-scan (Tekscan, Inc.vers. 6.34 Boston USA) in static conditions (standing) and dynamic conditions (taking a step on the Mat-scan). Plantar pressures (kPa) were determined at the five metatarsal areas, mid foot area, medial and lateral heel areas and medial three toes.
Results: Static and dynamic plantar pressures in both right and left feet were significantly higher in diabetic with neuropathy group than in control group in measured areas ($P < 0.05$). Static and dynamic pressures in right and left feet were significantly higher in diabetic with neuropathy group than in diabetic without neuropathy group in measured areas ($P < 0.05$). On comparison between controls and diabetic without neuropathy group there was a significant difference in plantar pressures especially in metatarsal areas ($P < 0.05$). No significant correlations were present between the studied variables age, disease duration, BMI and HbA1c and plantar pressures in all studied areas.
Conclusion: Persons with diabetic neuropathy have elevated peak plantar pressure (PPP) compared to patients without neuropathy and control group. HbA1c% as a surrogate for glycemic control had no direct impact on peak planter pressure, yet it indirectly impacts neuropathy evolution through out disease duration eventually leading to the drastic planter pressure and gait biomechanics changes.

1. Introduction

One of the most common and troublesome complications of diabetes is diabetic neuropathy with at least half of all diabetic patients including patients with type 1 diabetes develop the condition during their life time [1,2].

Over the past decades it was discovered that the major metabolic pathways thought to contribute to diabetic neuropathy included polyol pathway activity, oxidative stress, formation of advanced glycation end products and other inflammatory changes.

Abbreviations: BMI, body mass index; DN4, Douleur neuropathique 4 questionnaire score; M1, first metatarsal area; M2, second metatarsal area; M3, third metatarsal area; M4, fourth metatarsal area; M5, fifth metatarsal area; MF, mid foot area; MH, medial heel; LH, lateral heel areas; T1, T2, T3,T4,T5, five toe areas.

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They work together and interact in a mutually faciliatory fashion [3,4].

Diabetic polyneuropathy is a true polyneuropathy as all of sensory, motor and autonomic fibres become malfunctioning progressively [5,6].

A complex interaction of intrinsic factors that includes peripheral neuropathy, vascular disease, structural deformities and elevated planter pressure constitute the pathogenesis of diabetic foot ulceration. Raised dynamic planter pressure is found frequently among diabetics with neuropathy, also raised dynamic foot pressure have been shown to be significantly associated with developing foot ulcer among diabetics [5–8].

Few studies examined the relation of peak planter pressure with glycemic control reporting a weak correlation with Fasting blood sugar [9] while another study reported a significant positive correlation [10]. Thus the relation of planter pressure changes in diabetic patients remains unclear.

1.1. Objective

To examine Relationship of Planter Pressure and Glycemic Control in Type 2 Diabetic Patients with and without Neuropathy.

1.2. Subjects and methods

This study was conducted on Egyptian type 2 diabetic patients with and without diabetic neuropathy subjects who attended Diabetes outpatient clinic at Ain-Shams University Hospitals, Cairo, Egypt.

1.3. Study population

Eighty subjects participated in this study, fifty subjects diagnosed with type 2 Diabetes mellitus and thirty healthy volunteers.

The Inclusion criteria included type 2 Diabetes mellitus patients aged between 18 and 60 years. The exclusion criteria included history of previous amputation, associated foot wound and ulcers, presence of rheumatological disorders and other metabolic disorders

1.4. Study design

All subjects underwent the following:

Full medical history which included diabetes duration and noting of diabetic complications. Thorough medical examination including height, weight and waist circumference and calculation of body mass index (BMI)

Diagnosis of neuropathy through foot examination by testing of foot sensation using a 10 g monofilament or vibration, touch, pain, and ankle reflex, Inspection for presence of any foot deformity and finally by undergoing the Douleur Neuropathique 4 (DN4) questionnaire score [11].

1.5. Laboratory studies

Hemoglobin A1c testing. The Blood samples were collected from patients and control subjects. Total haemoglobin and HbA1c concentrations are determined after haemolysis of the anti-coagulated whole blood specimen. Total Hb is measured colori-metrically. HbA1c is determined immuneoturbidimetrically [12].

1.6. Pedobarographic evaluation

Plantar pressure assessment was done for all patients using the Mat-scan (Tekscan, Inc.vers. 6.34 Boston USA). Readings for average pressures were taken in static conditions (standing) and dynamic conditions (taking one step on the Mat-scan). Following the manufacturer's instructions, we completed calibration with subjects standing on the Mat scan to minimize errors. Tests were repeated five times for each condition and the mean values were reported in each condition. The pressure mapping was divided in five metatarsal areas (First metatarsal area = M1, second metatarsal area = M2, third metatarsal area = M3, fourth metatarsal area = M4, fifth metatarsal area = M5), mid foot area (MF), and medial heel (MH) and lateral heel (LH) areas. Five toe areas (T1, T2, T3 etc).

1.7. Statistical analysis

Data were processed and analyzed using SPSS PC for windows XP (Version 16)

2. Results

Subjects were stratified according to presence or absence of diabetic neuropathy. They were divided into three groups:

Group I: Twenty patients with type-2 diabetes mellitus with neuropathy

Group II: Thirty patients with type-2 diabetes mellitus without diabetic neuropathy.

Group III: Thirty control healthy volunteers.

Both Group I and II were matched for age and BMI.

2.1. Demographic data analysis

In Group I there were 3 males and 17 females, 15% of cases were males and 85% were females, In Group II there were 5 males and 25 females, 16%of cases were males and 84% were females, with a mean age of 55 ± 6.04 in Group I, and a mean age of 46.93 ± 5.06 in Group II, there were 21 males (70%) and 9 females (30%) in group III while the mean age for Group III (control) was 32.40 ± 6.40.

The mean disease duration was 10.4 ± 4.3 years in Group I and 4.9 ± 2.9 in Group II. On comparing groups regarding disease duration there was a significant difference between Group I and Group II.

Their mean BMI was 28.62 ± 2.35 kg/m^2 in Group I, 27.44 ± 1.65 in Group II and 27.91 ± 2.02 in control group (Group III). On comparing groups regarding BMI there was no significant difference between Group I and Group II ($p = 0.507$) while there was a significant difference between Group III and both Group I and II ($p < 0.01$).

Regarding HbA1c levels in Group I the mean was 10.36 ± 1.16 mg/dl, while in group II the mean was 8.18 ± 1.21 mg/dl, and 4.58 ± 0.33in Group III. On comparing groups regarding HbA1c levels there was a highly significant difference across all groups with a p value < 0.001. Post-hoc analysis showed a significant difference between Group I and Group II with a p value < 0.001.

Foot deformity was recorded as present or absent with regard to the following: Charcot mid-foot deformity, Hallux abducto valgus, pes planus (flat foot), pescavus (high arch), hammer toes, claw toes, calceneovarus, inverted foot. There was no significant difference in diabetic patients with and without deformities in Group I compared to Group II.

Patients were further sub-grouped according to diabetes duration where the number (n) of patients with diabetes duration less than 10 years were 35 (70%) and those with diabetes duration more than 10 years were 15 (30%). Percent of neuropathic patients in those with <10 years of diabetes duration was 22.9% while percent of neuropathic patients in those with >10 years of diabetes duration was 80%.

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