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Research Paper



Effect of Offloading Plantar Pressure on Peak Pressure in Ten Plantar Regions and Gait Speed in Men With Diabetes and Active Diabetic Foot Ulcers, and Healthy Men

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ABSTRACT

Background and Aims Diabetes is associated with dysfunction and damage in various organs due to abnormal pressure on ten plantar regions. This study aims to compare the effect of offloading plantar pressure on peak pressure of ten plantar regions and gait speed in men with diabetes and active diabetic foot ulcers, and healthy men.

Methods This is a causal-comparative study. Participants were 30 healthy men, 30 diabetic men and 30 men with active diabetic foot ulcers who needed no leg amputation according to their physicians. Sampling was done using random and convenience methods. Diabetic foot ulcers were classified based on the Meggitt-Wagner classification criteria, according to which grade 1 indicates a superficial ulcer and was used as a criterion for selecting people with diabetic foot ulcers. Plantar pressure variables were recorded using RScan software (RScan International, Belgium; 0.5×0.5×0.02 m, 4363 sensors) at a sampling frequency of 300 Hz and the gait speed was measured using a digital stopwatch. Correct walking considered as the full impact of the foot on the middle of the foot scan machine. Data were analyzed using independent t-test in SPSS software, version 24.

Results The peak pressure in the metatarsal 3 ($P < 0.001$), metatarsal 4 ($P = 0.020$), medial heel ($P = 0.004$) and lateral heel ($P = 0.007$) in the diabetic foot ulcer group significantly increased compared to the diabetic group. In addition, the peak pressure in the medial heel ($P = 0.013$) and lateral heel ($P = 0.019$) in the diabetic group significantly decreased compared to the healthy group.

Conclusion Men with diabetic foot ulcers are more exposed to abnormal peak pressures in different plantar regions, which can cause irreversible clinical injuries. Diabetic men have a lower gait speed than healthy men which can be important in their rehabilitation.

Keywords Peak pressure, Diabetes, Diabetic foot ulcers, Gait speed

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Extended Abstract

Introduction

The prevalence of diabetes is increasing in both developed and developing countries. The underlying causes of this disease include the lack of physical activity, eating high-calorie foods, and obesity. According to the International Diabetes Federation Atlas report in 2015 (seventh edition), the prevalence of diabetes in Iran, as one of the developing countries, was 5.97% (4.6 million people) and it was expected that this amount would increase to 12.19% (9.37 million people) by 2040. The lack of blood sugar control in diabetic people has long-term adverse effects and consequences including cardiovascular diseases, kidney failure, neuropathy, and foot ulcers. Diabetic foot ulcer is one of the most important complications of diabetes, the risk of which reaches 15% during the lifetime of diabetic patients. Each year, more than one million people with diabetes lose their legs due to this disease; i.e., leg amputation due to diabetes occurs every 30 seconds. Type 2 diabetes and peripheral neuropathy are common causes of foot ulcers, gangrene and amputation, such that the incidence of leg amputation due to foot ulcers in Iran is higher than the global rate. Studies in biomechanics have shown that diabetic foot ulcer is a mechanical phenomenon (pressure and force); factors such as neuropathy and structural abnormalities of the foot can increase pressure and force in the foot areas.

Caselli et al. (2002) [10] evaluated the forefoot-to-rear-foot plantar pressure ratio to evaluate the possibility of foot ulceration in diabetic patients with different degrees of neuropathy. They showed that the amount of forefoot and rearfoot pressures were higher in patients, but the ratio was increased only in patients with severe neuropathy, indicating that the imbalance in the distribution of plantar pressure proportional to the severity of neuropathy. In general, diabetes usually leads to bone abnormalities and high-pressure areas which cause fractures and skin ulcers. The majority of diabetic foot ulcers are due to repetitive mechanical stress during walking in case of peripheral neuropathy or loss of protective sensation. It seems that most neuropathic foot ulcers are formed due to mechanical loading on the numb foot during movement. Plantar pressure is an important biomechanical factor in the study of neuropathic foot. Although people with active leg ulcers feel numbness in the foot, they may still alter the characteristics of a protected gait strategy during barefoot walking to compensate their active ulcers. This highlights the possibility of a change in the gait of individuals with active foot ulcers, which is contrary to previous findings. The current study aims to investigate whether there is a difference in the offloading peak plantar pressure

in ten areas of the foot and gait speed between patients with diabetes and diabetic foot ulcers and healthy people.

Materials and Methods

This is a causal-comparative study. Participants were 30 healthy men, 30 diabetic men and 30 men with active diabetic foot ulcers who need no leg amputation according to the physician. Sampling was done using random and convenience methods. Diabetic foot ulcers were graded according to the Meggitt-Wagner classification criteria. According to these criteria, grade 1 indicates a superficial ulcer, which was used as the criterion for selection of people with diabetic foot ulcers. Plantar pressure variables were recorded using RScan software (RScan International, Belgium; 0.5 m×0.5×0.02 m, 4363 sensors) at a sampling frequency of 300 Hz during the support phase of walking and gait speed was recorded using a digital stopwatch. The peak plantar pressure was assessed in ten plantar areas including toe 1, toes 2-5, metatarsals 1-5, mid foot, medial heel, and lateral heel. In the present research, the validity and reliability of the test were obtained 0.81 and 0.88, respectively. Correct walking considered as the full impact of the foot on the middle of the foot scan machine. Data were analyzed using independent t-test in SPSS software, version 24.

Results

The results showed that the peak pressure in metatarsal 3 ($P<0.001$), metatarsal 4 ($P=0.020$), medial heel ($P=0.004$), and lateral heel ($P=0.007$) in the diabetic foot ulcer group significantly increased compared to the diabetic group. In addition, the peak pressure in the medial ($P=0.013$) and lateral ($P=0.019$) heels in the diabetic group significantly reduced compared to the healthy group.

Discussion

Men with diabetic foot ulcers are more exposed to the abnormal peak pressures in different plantar areas, which can cause irreversible clinical injuries. Diabetic men have lower gait speed compared to healthy men which can be important in their rehabilitation.

Ethical Considerations

Compliance with ethical guidelines

In this study, informed consent was obtained from the participants. They were assured of the confidentiality of their information and were free to leave from the study. This study was approved by the ethics committee of the Islamic Azad University, Central Tehran Branch (Code: 1194).

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Authors' contributions

Conceptualization and supervision: Ali Tavakoli and Farhad Tabatabai Ghomsheh; Methodology, data collection, data analysis, funding and resources: Ali Tavakoli Golpayegani; Review, writing—original draft, and writing—review and editing: all authors.

Conflict of interest

The authors declared no conflict of interest.

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