A FUNCTIONAL STUDY OF A NEW DIABETIC FOOT SHOE

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The purpose of this study was to test the function of a new diabetic foot shoe - BMWALKER which was designed for Chinese people in daily activities. The BMWALKER was compared with the DARCO shoe by means of plantar pressure distribution analysis and subjective wearing evaluation of diabetic patients. Both BMWALKER or DARCO diabetic shoes could reduce the pressure and impulse at the ball of foot (M2-5 metatarsus), thus balancing the pressure in the nine regions of the foot sole and abating the risk of damage due to high pressure and long time impact. The DARCO shoes dispersed the pressure of ball of foot and heel by better arch support. The BMWALKER shoes reduced the maximum pressure and impulse by increasing the effective load area at the metatarsal. Both shoes were found to function providing foot protection but the mechanism of reducing the pressure on the ball of foot was different between shoes.

KEYWORDS: diabetic foot shoe, pressure ditribution, comfort evaluation.

INTRODUCTION: Abnormal pressure distribution and increases of plantar pressure have been reported as independent risk factors for predicting the occurrence of diabetic foot ulcers (Coppini, Wellmer, Weng, et al. 2001, Kastenbauer, Sauseng, Sokol, et al. 2001). The diabetic foot shoe is a supplementary tool to prevent and mitigate these risks. Studies showed that the DARCO diabetic foot shoes could relieve foot pressure in patients with high foot pressure, corrected the abnormal distribution of foot pressure and reduced the incidence of foot ulcers in diabetic patients (Jayasinghe, Atukorala, Gunethilleke, et al., 2007, Beuker, van Deursen, Price et al., 2010). The DARCO type of diabetic shoe was designed originally on the people in American. The purpose of this study was to test the function of the BMWALKER diabetic shoe which was designed for Chinese people in daily activities. The BMWALKER was compared with DARCO by means of plantar pressure distribution analysis and subjective wearing evaluation of diabetic patients.

METHODS: The subjects were 10 middle aged and elderly diabetic patients. The average age, height and weight were 54.1 ±9.76 yr, 174.5 ±4.9 cm, and 76.5 ±6.6 kg respectively. Diabetic patients were enrolled at the risk stage of foot ulcers, but no ulcer patients at present, Subjects were screened by professional clinicians using foot pathological tests such as ankle brachial index (ABI) and diabetes foot probe sense. There was no history of amputation, severe joint disease, joint motion disorder, unstable walking and gait abnormalities in subjects.

The tests were performed in the Affiliated Hospital of Wuhan University of Science and Technology. All subjects wore firstly a reference shoes (a casual cloth shoes) and then DARCO or BMWALKER diabetic shoes allocated randomly in turn to complete the function tests. The function tests included the following actions successively: single foot still stand for 5 seconds, walking at normal speed along a 7 m straight path for three times, and up and down three times on a 11 stairs.

The plantar foot surface was divided into 9 analysis regions: T1 (first toes), T2-5 (2-5 toes), M1 (first metatarsus), M2-3 (2-3 metatarsus), M4-5 (4-5 metatarsus), MM (the medial arch of the foot), LM (the lateral arch of the foot), MH (the medial heel), and LH (the lateral heel). The average values of three tests of maximum pressure, effective load area and impulse in function tests were recorded by Novel Pedar-X system. A 14 continuous score questionnaire

survey on the shoes was completed by subjects after one function test with different shoes. The continuous scores were from 0 (most discomfort) to 150 (most comfortable). Variance analysis was used for data processing between groups. The level of significance was set to 0.05.

RESULTS: There were significant differences ($p<0.05$) on the pressure distribution parameter values between wore reference and BWWALKER shoes, reference and DARCO shoes in some regions of plantar.

There were significant differences ($p<0.05$) on the pressure distribution parameter values, including maximum pressure and/or effective load area and/or impulse, in regions of MM, LM, M1, M2-3, M4-5, MH and T2-5 between wearing BMWALKER and DARCO diabetic shoes during daily activities tests. The values of maximum pressure, when wearing BMWALKER and DARCO shoes were respectively 3.32 ± 2.28 and 9.25 ± 4.63 in single foot still stand; 3.57 ± 1.69m and 7.55 ± 4.51 in straight path walking; 5.75 ± 3.18 and 12.06 ± 5.37 in up down stairs; and 4.27 ± 2.16 and 11.08 ± 4.83 in the region of MM; 14.68 ± 5.97 and 28.36 ± 7.09, in single foot still stand; 8.66 ± 5.29 and 18.87 ± 5.99 in straight path walking; 12.56 ± 7.01 and 21.55 ± 8.8 in up and down stairs; 9.00 ± 4.35 and 22.01 ± 6.32 respectively in the region of LM; and 26.26 ± 9.29 and 31.41 ± 9.17 in straight path walking in the region of M2-3.

Among 14 questionnaire survey scores, there were significant differences in six scores ($p<0.05$).

Table 1: Comfort scores of shoes (X±SD)

Item	BMWALKER	DARCO
Overall comfort	115.4±14.50	85.8±12.63
Fit degree	115.6±15.07	84.1±12.98
Heel buffering	83.8±21.49	116.4±24.70
Friction between foot and shoe	47.3±18.40	85.3±22.29
Friction between shoe and ground	110.6±14.63	91.6±20.94
Weight of shoes	58.4±19.84	85.8±31.69

DISCUSSION: Compared with reference shoes in daily activities, there were lower maximum pressure and impulse at the ball of foot and lateral of arch and heel and larger effective load area in arch and toes when wearing BMWALKER shoes, lower maximum pressure and impulse in heel when wearing DARCO shoes.

Distribution parameter values of sole pressure were lower than that of DARCO shoes when wearing BMWALKER shoes: (1) Maximum pressure of MM and LM in all activities; M2-3 in single foot still stand. (2) Effective load area of MM and LM in all activities; M1 and M2-3 in straight path walking; M1 both in up and down stairs. (3) Impulse of MM and LM in straight path walking; up and down stairs; M1 in downstairs.

Distribution parameter values of sole pressure were higher than that of DARCO shoes when wearing BMWALKER shoes: (1) Maximum pressure of M4-5 in straight path walking; up and down stairs; MH in straight path walking. (2) Effective load area of M4-5 in single foot still stand and downstairs; T2-5 in upstairs; MH and LH in downstairs. (3) Impulse of MM and LM in single foot still stand; M4-5 in straight path walking; M4-5 and T2-5 in downstairs.

The subjective comfort and sensual scores of diabetic patients wearing DARCO and BMWALKER shoes were generally higher than those of reference shoes. Except the score of friction between foot and shoe, BMWALKER shoe scores were higher than that of DARCO in 5 scores of overall comfort, fit degree, heel buffering, friction between shoe and ground, and weight of shoes.

CONCLUSION: The maximum pressure and maximum impulse of diabetic patients in daily activities are concentrated in the region of metatarsal bone. Both DARCO or BMWALKER diabetic shoes could reduce the pressure and impulse at the ball of foot (M2-5 metatarsus), thus balancing the pressure in the nine regions of the foot sole and abating the risk of

damage due to high pressure and long time impact. The DARCO shoes dispersed the pressure of ball of foot and heel by better arch support. The BMWALKER shoes reduced the maximum pressure and impulse by increasing the effective load area at the metatarsal. Both shoes have the function of foot protection but the mechanism of reducing the pressure on the ball of foot was different between shoes.

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