Original Article

The characteristics of walking strategy in elderly patients with type 2 diabetes

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ABSTRACT

Objective: To explore the walking strategy by monitoring the characteristics of center of pressure (COP) of gait in the elderly with type2 diabetes.
Methods: All of the elderly patients with type2 diabetes (n = 543) were enrolled from Huadong Hospital Affiliated to Fudan University. Dynamic barefoot plantar pressure was assessed by Footscan7 USB2 flat. Outcome measures included excursion, the x- and y-coordinates displacement of COP and falling frequency.
Results: There were 64.5% of cases with abnormal COP trajectory. Among them, 45.2% were with abnormal fold-back, 14.0% with two or more abnormal fold-back, 20.5% with abnormal beginning point deviating from the heel to the arch and metatarsal region, 18.0% with abnormal terminal point deviating from the hallux to toe 2—5 and the x- and y-co-ordinates displacement of COP in both feet are asymmetry.
Conclusions: It highlights to put forward the walking strategy according to the abnormal COP trajectory. Due to the elderly diabetics with high risks of falling, the rehabilitation nursing should be strengthened mainly including the training of enhancing proprioception to prevent the elderly patients with type2 diabetes from falling.

1. Introduction

Older individuals with type 2 diabetes often exhibited greater impairments in posture and gait and were typically increasing risks of falling, which may be related to characteristics such as aging and diabetes itself. It reported that the impairments usually included atrophied leg muscles and plantar fat pad, development of claw toes and hammer toes, limited joint mobility [1], plantar sensory loss, and poor ability to readjust the way [2]. These structural and functional abnormalities of the foot were associated with changed walk strategy and abnormal gait, eventually leading to an increased risk of falls. Falls could not only reduce mobility and independence in the elderly, but also cause substantial morbidity and mortality [3]. Balance disorders and gait abnormalities were the most important reasons of falls in elderly patients with type2 diabetes, and it was essential to assess their gait characteristics to predict the extent of fall risk [4].

While gait has been extensively studied in elderly patients with type2 diabetes, such as gait cycle, time phase, pace, the COP would evaluate biomechanical parameters by more useful and accurate information on the anatomical structures acting in and on the foot during walking. The COP recorded the succession of instantaneous positions during the entire period of contact between foot and floor and was plotted as a sequence of points on the ground plane. It took into account the displacement of load throughout the foot during the stance phase of a walking cycle. More specifically, spatial evolution of COP along the longitudinal axis of the foot mainly depended on the articular mobility of tibio-talar and metatarso-phalangeal joints in the sagittal plane. The former joint allowed the foot to roll over the ground during the initial contact phase; the latter manages the toe-off phase. COP excursions along the medio–lateral axis of the foot mainly depended on the inversion-eversion movements made to better control landing, energy storage, and propulsion. Such movements were performed by subtalar and minor foot joints in the frontal and transversal planes. Several articles [5–7] dealt with the importance of COP pattern alterations during gait, and some of them report the definition of COP indexes for measuring abnormal COP displacements.

The purpose of this study was to monitor the characteristics of COP, explore the walking strategy by measuring dynamic barefoot plantar pressure in elderly patients with type2 diabetes and assess the situation of falling in order to provide the basis for the establishment of abnormal plantar pressure correction system, stability of their gait and reduce occurrence of falls.

2. Subjects and methods

2.1. Subjects

This study was conducted at the endocrine ward of Huadong Hospital Affiliated to Fudan University from April 2012 to October 2014. All diabetic patients who were treated in the department of endocrinology during this period were recruited. The inclusion criteria included: diagnosed as type2 diabetes under stable metabolic control, ≥ 60 years old, having the capability to remain in an orthostatic position without assistance or using auxiliary devices while the exclusion criteria contained that along with current foot ulcer, bilateral foot amputations, wheelchair-bound or unable to walk, too sick to participate, or psychiatric illness that prevented informed consent were excluded. All subjects provided informed consent prior to participating in the study. The study protocol was approved by the Ethical Committee of Huadong Hospital Affiliated to Fudan University.

2.2. Methods

In this study, a general information form designed by the researcher was used to collect demographic characteristics. Additionally, Footscan7 USB2 flat, used to evaluate the biomechanical parameters such as COP, was a floor-mounted capacitance transducer matrix platform (Novel Rscan, Belgium).

2.2.1. General information form

Demographic characteristics mainly included personal details, such as gender, age, height and weight.

2.2.2. Plantar pressure platform

The platform was made of a matrix of resistive sensors spaced 40 cm × 100 cm with a sensor resolution of 4 sensors/cm^2 sampling at 300 Hz. The parameters were calibrated before measuring to insure the veracity of COP. The platform was inserted at a level in the middle of a wooden walkway that was long enough to ensure that the acquisition was made "at regimen". The patient was trained to walk barefoot on the walkway at his or her preferring speed in a natural way and to center the active surface with one foot only without putting down on the platform. For each foot of every one, ten specific sub-areas were accurately selected: the first toe (T1), the second to fifth toes (T2-5), the first metatarsal head (MH1), the second metatarsal head (MH2), the third metatarsal head (MH3), the fourth metatarsal head (MH4), the fifth metatarsal head (MH5), the mid-foot (MF), the heel medial (HM) and the heel lateral (HL). Outcome measures included: (1) COP trajectory; (2) the number and location of the reentry of COP trajectory; (3) initially landing site; (4) ultimately off site; (5) the x- and y-coordinates displacement of COP; (6) falling frequency.

2.3. Statistical analysis

Data were analyzed using the SPSS statistical version 22.0. Data were reported as mean and SD or absolute and relative frequencies. The paired t-test was used for the comparison of the X, Y-axis displacement of the left and right foot. A significance level of 5% was adopted.

3. Results

3.1. Demographic data

We enrolled 543 elderly patients with type2 diabetes (262 men, 281 women) in this study. Participants were aged between 60 and 89 years old (mean 71.93 ± 7.3), the height were 64.32 ± 11.09 kg and the weight were 164.6 ± 10.6 cm.

3.2. Normal gait cycle

Gait cycle was analyzed at four phases [8]: (1) at heel strike; (2) at mid-stance; (3) at terminal stance; (4) at toe-off. (Fig. 1)

3.3. COP pattern in elderly patients with type 2 diabetes

This section contained the main results of the spatial and temporal COP pattern in elderly patients with type 2 diabetes, which well described how the foot interacted with the floor. Fig. 2 showed the 64.5% of all patients were with abnormal COP trajectories, details as following:

There were 45.2 percent with abnormal fold-back, of which 31.0 percent were with two or more abnormal fold-back and 77.1 percent were located at the arch.

In the aspect of abnormal beginning point according to COP trajectory, a total of 20.5 percent started from the non-heel