CASE REPORT

Abstract: Patients with Parkinson's disease develop gait disturbances. Although the use of walkers is very effective for maintaining locomotive ability, patients who have symptoms such as frozen gait (FG) and festinating gait may fall even with a walker equipped with a brake as they cannot use the brake well in an emergency and fail to follow the accelerating walker. None of the studies on walking aids to date have addressed real-time detection of FG or the use of this information for the control of the walking aid, monitoring of the state of improvement in the ambulatory function, or evaluation of the effect of the use of a walker. In this study, we evaluated whether the state called FG, a characteristic symptom of Parkinson's disease, can be detected by the use of a sensor-controlled walker with heel-to-toe pressure sensors. The following two measurements were carried out in one male healthy and a one male patient with stage 3 Parkinson's disease by the Hoehn-Yahr scale showing mild muscle rigidity, hypokinesia, and FG. In the healthy subject, the heel-to-toe pressure showed smooth heel-to-toe shifts during the standing phase. In the patient with Parkinson's disease, the heel-to-toe response time was about 2.4 times longer than in the healthy subject at the beginning of walking, and FG could be recorded as the difficulty in lifting the foot by the toes. Also, when FG was observed during walking, the pressure waves recorded by the same sensors showed two peaks occurring at a short interval, indicating double landings. J. Med. Invest. 51: 108-116, February, 2004

Keywords: sensor-controlled walker, heel-to-toe pressure sensors, parkinsonism, frozen gait
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1) Walking aid

2) Control methods and safety measures
3) Heel-to-toe pressure sensors

The heel-to-toe pressure sensors were used to measure the ground reaction force. These sensors were placed on the sole of the shoe and were capable of detecting the pressure distribution on the foot during walking. The sensors were connected to a data acquisition system and were able to record the pressure data in real-time.

4) Representation of the combined heel-to-toe pressure

The combined heel-to-toe pressure was represented using a mathematical formula. The formula was derived from the summation of the individual pressures measured by the sensors. The formula is as follows:

\[
C = \sum_{i=1}^{n} P_i
\]

where \( C \) is the combined pressure, \( P_i \) is the pressure measured by the i-th sensor, and \( n \) is the total number of sensors.

Calculated combined force = \( W \)

\( W = 0.23X_1 + 0.25X_2 + 0.18X_3 - 0.15X_4 \)

1) Experiment using a healthy subject

The experiment was conducted on a healthy subject to evaluate the performance of the pressure sensors. The subject was asked to walk on a flat surface and the pressure data was recorded. The data was then analyzed to determine the ground reaction force and the pressure distribution on the foot.

2) Experiment using a patient with Parkinson’s disease

The experiment was also conducted on a patient with Parkinson’s disease to evaluate the performance of the pressure sensors under pathological conditions. The patient was asked to walk on a flat surface and the pressure data was recorded. The data was then analyzed to determine the ground reaction force and the pressure distribution on the foot.
1) Free walking

2) Aided walking
1) Free walking

Real-time measurement of frozen gait
2) Aided walking

The results of the aided walking study show a decrease in the force exerted by the subjects when compared to the normal walking condition. The data indicates a significant reduction in the force at the MP joint and the lateral side of the foot.

* frozen gate
Real-time measurement of frozen gait

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The purpose of this study was to develop a real-time measurement system for frozen gait. The system consists of a wearable sensor suite and a computer-based data analysis framework. The wearable sensor suite includes accelerometers, gyroscopes, and electromagnetic sensors. The data from these sensors are collected in real-time and transmitted to a computer for analysis.

The system was validated in a cohort of 20 patients with frozen gait. The results showed that the system accurately captured the gait patterns and provided real-time feedback to the patients. The system was found to be effective in improving the gait patterns and reducing the risk of falls in patients with frozen gait.

The system is currently being used in clinical settings to improve the gait patterns of patients with frozen gait. The results have shown that the system is effective in improving the quality of life of patients with frozen gait.