STUDY OF NEW MEASUREMENT METHOD FOR CENTER OF PRESSURE AND FOOT SHAPE

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INTRODUCTION

Evaluation of the center of pressure (COP) in walking analysis is an important indicator in determining whether walking is efficient, and it is often used in design conformance evaluation for shoes and arch supports.

The main evaluation methods use ground reaction force plates and insole-type pressure sensors.

With ground reaction force plates, it is difficult to identify the location of the COP position even if the COP trajectory is shown.

With insole-type pressure sensors, the maximum pressure point in the plantar surface can be determined, but since these sensors use pressure-sensitive conductive ink, their precision is low compared with force plates. Moreover, because they are inserted into shoes, it is difficult to make evaluations with bare feet.

In this study, using a force plate and three-dimensional motion analyzer, we devised a system that measures COP coordinates in the plantar surface.

METHOD

The subjects were 10 healthy female university students and 20 feet. The task was normal walking. The measurement devices used were 12 three-dimensional motion analyzers with infrared cameras and six force plates.

The subjects wore sportswear and leggings, and were barefoot. Infrared reflection markers with a diameter of 10 mm were attached in 18 places each leg and foot. The markers were attached on the first, second, and fifth distal phalanxes, metatarsal head, metatarsal base, navicular tuberosity, foot high point, sustentaculum tali, peroneal trochlea, and calcaneal tuberosity.

The measured marker coordinate positions and ground reaction force were calculated using Body Builder data processing software, and synchronized using Scilab numerical calculation software. With regard to the foot position, the timing at which the value of each marker was the smallest on the Z-axis was judged to be a state of contact with the floor.

The foot shape measures were foot length, foot width, and navicular bone height. The values calculated from the distance between markers were compared with manual measurements made using a foot gauge, measuring tape, and height gauge.

Tests of significant differences between the two groups were done using a two-tailed Wilcoxon t-test, with <5% indicating statistical significance.

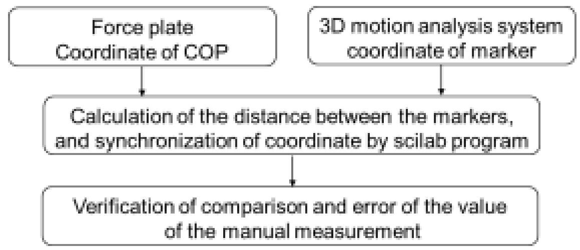

Figure 1. Procedure of analysis

RESULTS

No significant differences were seen between any of the items, and the error between manual measurements of foot shape and the new measurement method was approximately 1–2 mm. The trajectory of the COP in the plantar surface could be shown by synchronizing the foot marker coordinates and COP coordinates.

	Error(mm)	Significance difference
Foot length	**1.3±0.6**	n.s.
Foot width	**1.4±0.3**	n.s.
Navicular bone height	**1.7±1.2**	n.s.

Figure 2. Error and Significance difference

DISCUSSION

The small error between the manual measurements and the measurements with the new method likely stems from the bone landmarks projecting from the vertical plane, and being attached so that they were superimposed on the center of the markers.

It is conjectured that since the calcaneal markers could not be projected vertically from the calcaneal shape, the error could be corrected by adjusting the position at which the markers are attached to the distal phalanx of the hallux.

CONCLUSION

The proposed method overcomes the disadvantages of using force plates and insole-type pressure sensors for evaluation of the COP in walking analysis.

CLINICAL APPLICATIONS

The COP trajectory was obtained with high precision even with measurements in bare feet, and useful in evaluating walking efficiency.

American Academy of Orthotists & Prosthetists
43rd Academy Annual Meeting & Scientific Symposium
March 1-4, 2017