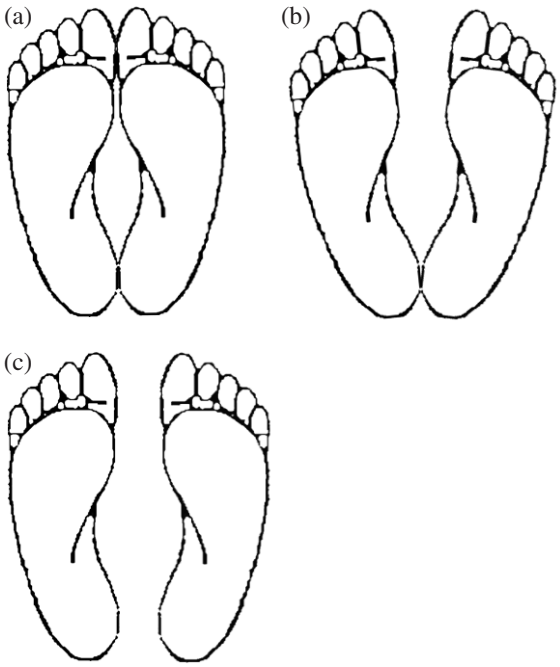

Fig. 1. Arrangements of soles in each posture: (a) the Romberg's posture, (b) a posture with open toes and heels together, and (c) a posture with parallel feet.

3. A Problem of the Clinical Stabilometry and Solution

Stabilometry is generally performed in Romberg's or Mann's posture. Romberg's posture is an upright posture with the bilateral toes and heels together. Body sway increases in inversely to the area of the supporting base because these are unstable upright postures with a small support area; therefore, stabilometry in upright postures is not appropriate in subjects having difficulty maintaining a standing position for a certain amount of time. Elderly persons and the patients in equilibrium e.g. Meniere disease may have difficulty sustaining this upright posture because their balance-retaining ability is impaired by aging and muscle weakness (Stevens and Patterson, 1995). Romberg's posture with a narrow support area may increase the risk of falling, and hence, preventive countermeasures are necessary. Excluding unstable upright postures with a small support area or proposing surrogate postures for the stabilometry, we can prevent subjects from falling down on the floor.

Accordingly, changes in the standing position control system resulting from disturbance or abnormal body equilibrium function are reflected with greater sensitivity of the abovementioned unstable postures with a narrow support area. Stabilometry can usually detect the deterioration in the equilibrium function. Because the control system to maintain these postures is unstable, it is important to introduce the abovementioned surrogate postures to the stabilometry

1. in which subjects are theoretically considered not to fall down;

2. which can detect the deterioration in the equilibrium function.

In addition, few studies have succeeded in findings of potential functions (3) to control upright postures except for the Romberg's posture. Thus, we herein introduce

I. a posture with open toes and heels together

II. a posture with parallel feet

to the stabilometry (Fig. 1).

We compared histograms that were composed of all subjects' stabilograms (Appendix A). The frequency of an x coordinate near the origin was greater in the postures I and II than in the Romberg's posture. When the histograms for the Romberg's posture and the posture I were compared in the x and y directions, with open and closed eyes, using the chi-squared test, no significant differences were observed. However, there is a significant difference between histograms for the Romberg's posture and the posture II in the x direction. Thus, the system to control the upright posture I is regarded as the same system to maintain the Romberg's posture because potential functions to control upright postures (Fig. 2) can be obtained from the histograms in accordance with Eq. (3). However, the system to control the upright posture II is not regarded as the same system.

4. Future Research Directions

In previous studies on the body sway, stabilometry was generally performed in Romberg's posture. However, the balance-retaining ability decreases with aging, and the risk of falling is increased for elderly subjects in tests using Romberg's posture because it is an unstable upright posture. There is also an increased risk of falling when the technique is used for diagnosing diseases (e.g., Meniere disease, sudden deafness accompanied by vertigo, and vestibular neuronitis), measurement of body sway, and course observation of vertigo and impaired balance function. If the risk of falling during the test can be reduced by performing stabilometry in the posture with heels together, additional studies are needed to further develop and validate the technique for application in medical practice.

The indices calculated from the stabilograms indicated that the standing position in Romberg's posture was less stable in both young and elderly subjects (Yoshikawa *et al.*, 2013). However, no significant differences were also noted in the analytical parameters between Romberg's posture and the posture I in the elderly subjects, which is consistent with the result of this paper; therefore the posture I may be used in stabilometry as a substitute for Romberg's posture in elderly persons.

The temporal averaged potentials in Romberg's posture were determined from the histograms using Eq. (3) in the elderly subjects (Fig. 2). The shapes of the potentials were more complex and tended to be nonlinear in the Romberg's posture and the lateral component x because coefficients of the regression polynomials (Appendix A) were less than 0.9 in several cases (Tables 1 and 2). Multiple minimal points in the potential function have been obtained from each healthy young subject in accordance with the theory mentioned in Section 2 (Takada *et al.*, 2001). Especially in the posture II, two minimal points in the potential function might correspond to each center of the sole. In the next step, we will quantitatively examine whether distance between open toes changed the potential function in the posture I.