Supplement III

1. Methods: Gait and balance analysis

Gait analysis: Tekscan Walkway (Tekscan Inc., USA) was used to measure dynamic plantar pressure distributions during walking for test subjects (**Figure 1**). This walkway was 3 meters long, consisting of 4 sensors per cm^2 sampling at a rate of 100 Hz. Subjects were asked to walk at a comfortable, self-chosen pattern and allowed to familiarize themselves with the procedure and equipment before data collection. Peak pressure of the whole foot and pressure of two major RIOs: forefoot and rearfoot were collected during the stance phase of walking. Pressure values were also recorded for analysis suing published protocol.[1]

Balance analysis: SMART EquiTest® (NeuroCom International, Inc., USA) was used for assessing static postural stability (SPS) or balancing capabilities of the subjects that were compared with built-in normal database values of Chinese females.[2] Briefly, a force platform within the system recorded the displacement of center of pressure (CoP) where the subjects were required to complete three stance conditions, i.e. (a) bipedal stance with eyes open (BiSEO), (b) bipedal stance with eyes closed (BiSEC) and (c) single-leg stance with eyes open (SLSEO), with bare feet placed on the markings of the force platform. Data were acquired at 100Hz over a period of 20 seconds in conditions (a) and (b), and 10 seconds in condition (c). Each condition was performed thrice and maximum CoP displacements in antero-posterior (AP) and lateral directions were extracted (**Figure 2**). In conditions (a) and (b), participants stood at shoulder width; in condition (c), participants performed single-leg stance tests on dominant leg.

Analysis: Plantar pressure distribution charts were directly compared between the right foot of the bound feet lady and that of a weight adjusted normal control of similar age. What to note is that only two women with bound feet from Luliang to be invited to Hong Kong and data were compared with Hong Kong local women. The accuracy of the dada could be confounded by lifestyle difference where more active lifestyle is normally associated with better gait and balance. However, the major difference should be explained by foot anatomy, with significant small foot size in women with bound feet as compared with that of women with normal foot.

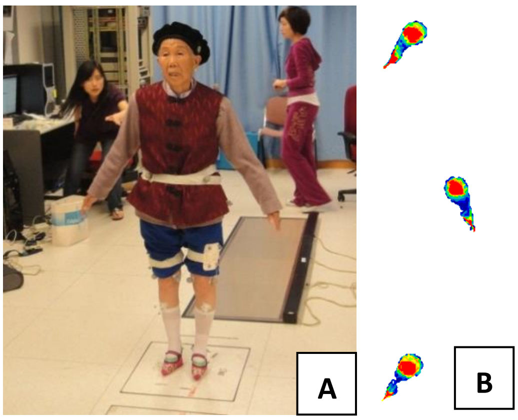

Figure 1 Walking gait patterns: Tekscan Walkway System was used to analyze lady with bound feet (A) and a typical example of a three step gait of a woman with bound feet (B).

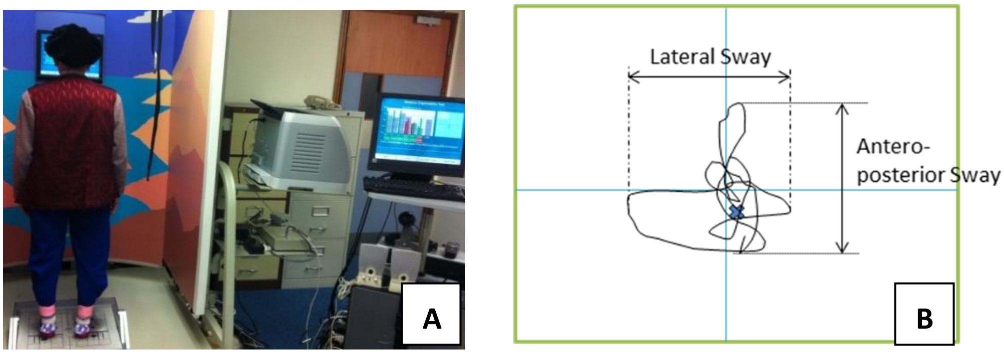

Figure 2 Static Posture Stability (SPS) assessment using SMART EquiTest® (NeuroCom International, Inc., USA) (A) and the displacement of center of pressure (B).

2. Findings

Gait analysis **Figure 3** displays feet force during stance phase. The force during propulsion of the stance (gait) phase for control subject is shown to occur at the forefoot while for women with bound feet, the force occurs at the rearfoot while the forefoot contributes only a minor force in its total pressure exerted. Foot binding thus shifts the center of gravity towards the heel. Moreover, the rearfoot contact time is found prolonged in bound feet women. For the control subjects, the rearfoot contact begins with the heel strike during the beginning of the stance phase (0%) and ends at the heel rise (80% of stance phase). For bound feet women, the heel contact time is prolonged to over 90% of the stance phase. The forefoot contribution to the propulsion is also only seen at the very end of stance phase. The difference in accumulated plantar pressure distribution between a normal and a woman with bound foot is demonstrated where the bound feet lady shows a much larger degree of pressure placed on the calcaneus of the heel and less force distributed over the forefoot in comparison to a normal foot (**Figure 4**).

Balance test **Figure 5** summarizes SPS measurements of two women with bound feet in comparison to data from the gender- and age-matched control database. Overall, the results indicate no obvious differences in all three categories of anterior-posterior and lateral sway compared with between women with bound feet and the controls, including degree of sway in bipedal stance with eyes open (BiSEO), bipedal stance with eyes closed (BiSEC), and single-leg stance with eyes open (SLSEO).

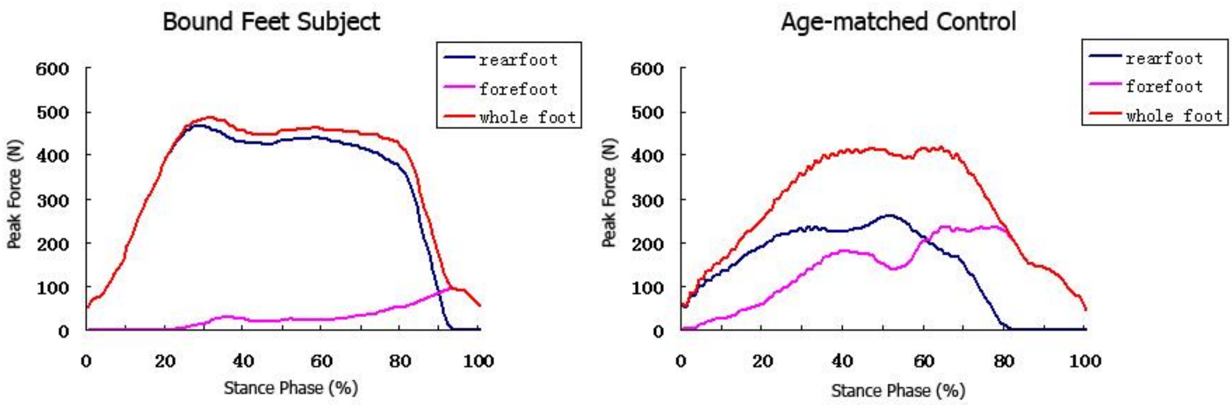

Figure 3 Representative foot force compared between subjects with bound feet and gender- and age-matched control, showing that a bound feet lady places almost the entirety of her foot force on the rearfoot for the predominant part of the stance phase with prolonged contact time, while the forefoot contributes to the propulsion only at the very end of the stance phase (Left). A gender- and age-matched control subject shows a more balanced pressure distribution of the rear and forefoot (Right).

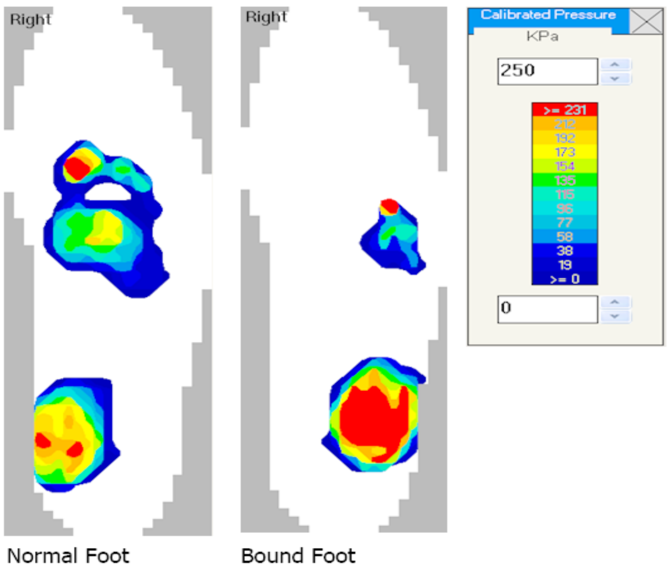

Figure 4: Comparison of representative plantar pressure distribution in women with normal feet and bound feet: regions in red represent areas of highest pressure (>231 kPa), while regions in blue represent areas of lowest pressure (>0 kPa).

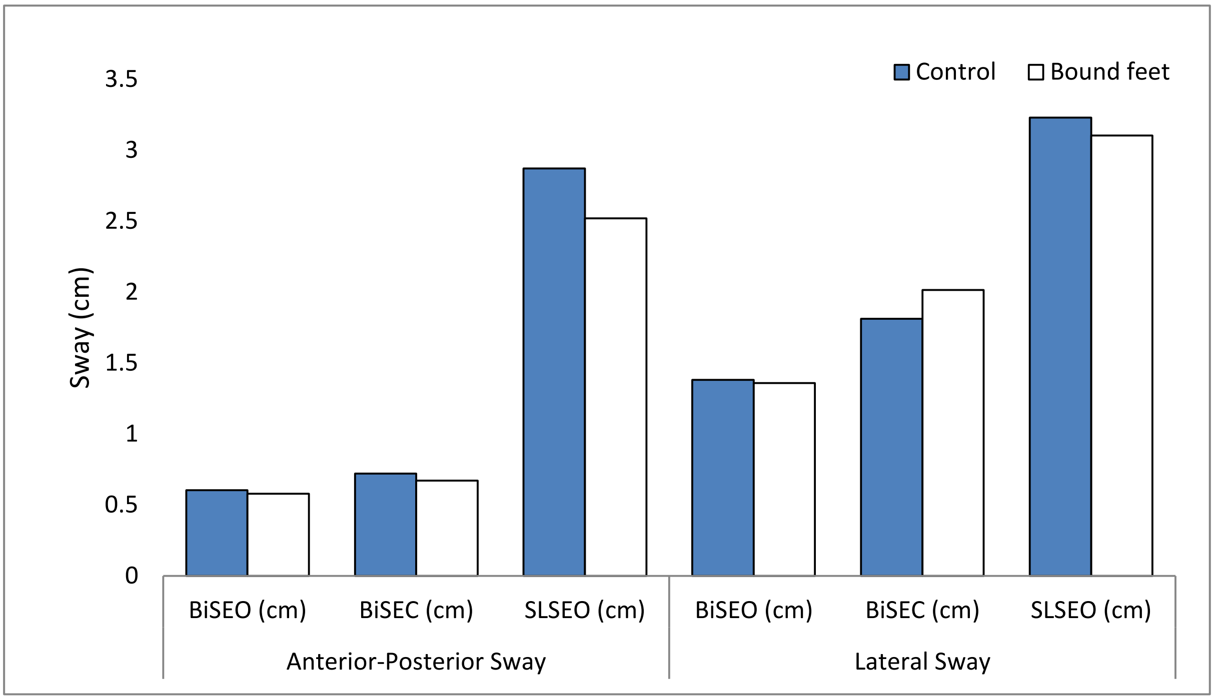

Figure 5: Static postural stability (SPS) balance test shows no obvious difference in both anterior-posterior and lateral sway categories compared for the mean of two women with bound feet and the gender- and age-matched reference population database. BiSEO: bipedal stance with eyes open; BiSEC: bipedal stance with eyes closed; and SLSEO: single leg stance with eyes open.

Specification of the relevant anthropometric information of the subset of the women with bound feet for gait and balance tests: both of them were also within the range but slightly above the average of women with bound feet with BW 48.2 and 47.5 kg; while with BMI of 21.0 and 20.6, respectively. This number is close to the mean of the control group (refer to Table 1).

A small subset was tested for gait and balance using state-of-the-art facilities and the data suggested that in spite of variation in gait patterns, the balance capability were similar irrespective of size of the feet, i.e. significantly smaller in manmade small feet in women with bound feet. Since the subjects were old and were not able to delineate if the previous fracture was a result of fall or spontaneous fracture due to poor bone quality, the overall findings however might still imply the essential role of body balance in prevention of fragility fracture.

Key Reference:

1. Mak AF, Zhang M, Boone DA. State-of-the-art research in lower-limb prosthetic biomechanics-socket interface: a review. *J Rehabil Res Dev.* 2001; 38(2):161–74.

2. Cheing GL, Chau RM, Kwan RL, Choi CH, Zheng YP. Do the biomechanical properties of the ankle-foot complex influence postural control for people with Type 2 diabetes? *Clin Biomech* 2013; 28(1):88-92.