Evaluation of different hindfoot kinematics according to various shoe-types during walking using a bi-planar fluoroscopy

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INTRODUCTION:

The introduction of bi-planar fluoroscopy enables direct visualization of motions between the multiple tarsal bones in the evaluation of foot and ankle kinematics. Unlike skin marker based models, it could possibly evaluate the kinematic effects of various shoes or orthotics. This study aimed to investigate different hindfoot kinematics (ankle, subtalar, talonavicular, and calcaneocuboid joints) according to various shoe-types during walking using a bi-planar fluoroscopic system (KMC-1400ST, Gemss Medical, Gyeonggi-do, South Korea).

METHODS: This study was approved by the institutional review board and informed consent was obtained from each participant. Fifteen healthy subjects (five males and ten females; mean age 23.3 years and SD 1.7 years) were enrolled and divided into three groups; group 1 (five males), group 2 (five females), and group 3 (other five females). All subjects underwent three dimensional CT examination, and bi-planar fluoroscopic images were capsured during stance phase of gait for four different shoe-types: group 1, barefoot, walking shoe, rocker bottom shoe and high-top climbing shoe; group 2, barefoot, walking shoe, highheel and rocker bottom shoe; group 3, barefoot, walking shoe, highheel, and high-top climbing shoe. 3D/2D registration algorithm was repeated each bi-planar fluoroscopic image using MATLAB (Mathworks, Natick, MA, USA) and VTK (Kitware, Clifton Park, NY, USA) and kinematic data of ankle, subtalar, talonavicular, and calcaneocuboid joints were calculated using the anatomical coordinate system.

RESULTS:

All shoe-wears tended to decrease ankle dorsi-plantar flexion motion compared with barefoot during gait. Range of ankle dorsi-plantar flexion was smallest in rocker bottom shoe walking, followed by high-top climbing shoe, walking shoe, and barefoot in male subjects. Range of ankle dorsi-plantar flexion was smallest in rocker bottom shoe walking, followed by walking shoe, high-top climbing shoe, high heel, and barefoot in female subjects. Range of inversion and internal rotation of the ankle joint was largest in rocker bottom shoe walking in male and female subjects although the value was relatively small. Effect of shoe-wears on subtalar, talonavicular and calcaneocuboid joints was not prominent.

DISCUSSION AND CONCLUSION: Different shoe-types could affect the ankle joint motion. In this study, shoe-wears decreased range of ankle dorsi-plantar flexion while they showed little effect on subtalar, talonavicular, and calcaneocuboid motion. Further study is required including larger sample size and various walking conditions such as slope walking, different walking speed, and irregular surfaces.