ISB 2013 BRAZIL
XXIV CONGRESS OF THE INTERNATIONAL SOCIETY OF BIOMECHANICS
XV BRAZILIAN CONGRESS OF BIOMECHANICS

Evaluation of ankle joint motion from single-plane radiographic projections during barefoot and shod running.

Akiyama, K., 1, Fukano, M., 2, Fukubayashi, T., 2

1: Graduate School of Sport Science, Waseda University, Japan

2: Faculty of Sport Science, Waseda University, Japan

INTRODUCTION

The optimal shoe structure during shod running allows functional adaptation in various dynamic situations. However, function of the ankle joint during shod running requires further investigation. Accurate knowledge of the in vivo ankle joint complex (AJC) during shod running is critical for understanding it functions during performance of sports. It may also contribute toward improvement of shoe design. The purpose of this study was to investigate the in vivo kinematics of the human AJC during shod running.

METHODS

subject

Five soccer players of male (age, 25.0 ± 3.4 yr; body height, 173.6 ± 4.7 cm; body mass, 74.0 ± 13.5 kg; mean ± standard deviation (SD)) with medial tibial stress syndrome and Five asymptomatic control subjects. Subjects in the MTSS group had been diagnosed with MTSS within a period of six months by an experienced orthopedic surgeon. MTSS was defined as exercise induced pain in the posteromedial aspect of the tibia, and pain in the posteromedial tibia on palpation of at least 5 cm. Patients had experienced symptoms for at least two weeks (Yates and White, 2004).
Six soccer players of male (age, 25.0 ± 3.4 yr; body height, 173.6 ± 4.7 cm; body mass, 74.0 ± 13.5 kg; mean ± standard deviation (SD)) without orthopedic abnormalities in their lower legs provided written informed consent to participate in the present study.
The study protocol was approved by the Ethics Committee of Waseda University.

Each running trial was recorded using cineangiography (INTEGRIS BH5000R.1, Philips, Amsterdam, the Netherlands). Images were obtained at a rate of 60 Hz, using a radiation exposure equivalent to 200 mA (1 ms) with an intensity of 50 kV and a spatial resolution of approximately 0.45 mm. This maximum sampling rate was selected as optimal for use with the Integris clinical examination apparatus, which is specific to the cardiac domain.
Geometric bone models of the tibia and talus/calcaneus were created from computed tomography scans (IDT 16, Philips) of the lower portion of one leg. Anatomical coordinate systems were embedded in each bone model following a combination of previously reported approaches.
After modeling of the tibia and talus, the calcaneus models were matched with the orthogonal images. The in vivo ankle positions were then reproduced from the three-dimensional ankle model. The following two types of AJC motion were examined: motion of the talocrural joint (relative motion of the talus with respect to the tibia) and motion of the subtalar joint (relative motion of the calcaneus with respective to the talus). The ankle positions at different time intervals were then reproduced from a series of three-dimensional ankle models from heel contact to heel off during running.

RESULTS AND DISCUSSION

From heel contact to heel off, significantly larger range of plantar flexion motion was observed in the talocrural joint compared with that in the subtalar joint during barefoot running. The internal/external rotation and inversion/eversion angles of the two joints were similar during barefoot running. In addition, all translations (along the x, y, and z axes) of the two joints were similar. The contribution of the subtalar joint toward active supination/pronation motion was greater than that of the talocrural joint. Rotations of the subtalar joint during shod running were smaller than those during barefoot running.
The kinematic data obtained in this study may have important clinical implications. Knowledge of in vivo AJC motion during normal closed kinematic chain motion (stance phase of running) is important. These results add quantitative data to an in vivo database of normal subjects that can be used for clinical diagnosis, treatment, and evaluation of the AJC after injury and may also be useful for shoe design.

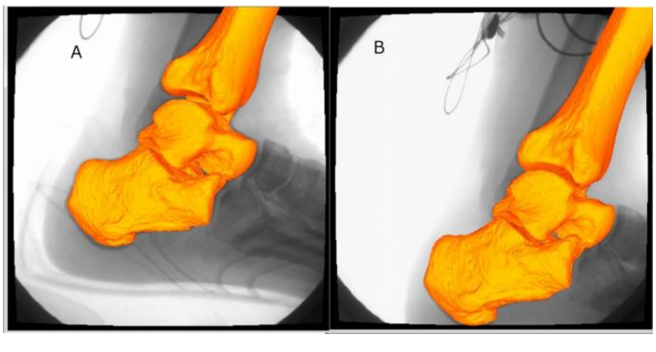

Figure 2: An example of the single-plane radiographic projections. A: Shod running B: Barefoot running

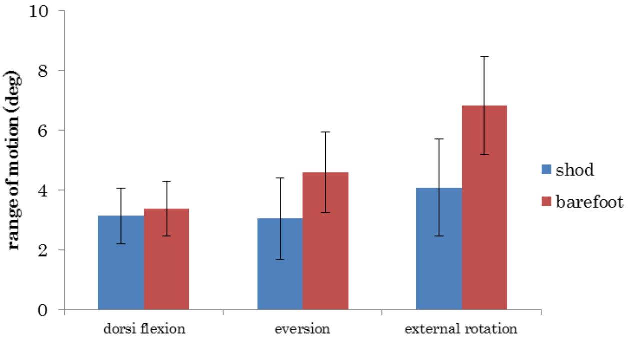

Figure 2: Range of subtalar joint motion during shod and barefoot running stance

CONCLUSIONS

AJC characteristics were described in this motion study. The results of this study showed differences in deformation patterns between joints during running. In addition, joint motion differed during shod and barefoot running. The data presented here provide inputs for future shoe design.

REFERENCES

1. Moro-oka TA, et al., *J Orthop Res*. **25(7)**:867-872, 2007.
2. Banks SA, et al., *IEEE Trans Biomed Eng*. **43(6)**:638-649, 1996.
3. de Asla RJ, et al., *J Orthop Res*. **24(5)**:1019-1027, 2006