KINEMATICS AND ELECTROMYOGRAPHY OF TRUNK AND LOWER-LIMB DURING WALKING WITH NEGATIVE HEEL SHOES

Jingxian Li[1] and Youlian Hong[2]
[1]School of Human Kinetics, University of Ottawa, Canada,
[2]Department of Sports Science and Physical Education,
The Chinese University of Hong Kong, China

INTRADUCTION: A type of negative heel shoes (NHS) was designed for the purpose of training the muscles in trunk and leg. The negative heel shoes are characterized as having the heel section lower than the toe when the top of the shoe and the insole are removed. The shoe itself tilts the foot into about 10 degrees of dorsiflexion. It is noteworthy that the original objectives of the NHS designer were to build up and exercise the muscles in trunk and lower-limn as well as Achilles tendon. However, studies about the kinematics and muscle activities of trunk and lower-limb in walking with NHS are limited (Benz, et al., 1998). And no scientific evidence supports that walking with the negative heel shoes benefits the muscle strength. The purpose of the present study was to investigate the kinematics and EMG activity in the muscles of trunk and lower-limb, as compared with walking with normal shoes. It is hoped that the results of this study will further the understanding of the effect of walking with NHS on biomechanical responses in humans.

METHODS: 13 healthy female university students (age 23.18 ± 3.9 years, body weight 50.18 ± 5.3 kg, and body height 1.63 ± 0.05 m) participated in the study. Two types of shoes, normal shoes with 1.5 cm higher heel and NHS with the toe was 1.5 cm higher than the heel, were tested. Reflective makers were attached to the right side of the subject at six anatomic positions (acromion, greater trochanter, lateral epicondyle of the femur, lateral malleolus, calcaneus, and head of the fifth metatarsal). Each subject was asked to walk on a treadmill with normal shoes and NHS at 1.33 m/s for 6 minutes. The walking movement was filmed by a 3-CCD video camera (50 Hz), set at a 1/250 s shutter speed and positioned lateral to the subject with the lens axis perpendicular to the plane of movement. The recorded video tapes were digitized and analyzed on the motion analysis system (APAS, USA). Maximum and minimum joint angles of trunk, hip, knee, and ankle, range of motion (ROM), stride cycle time, cadence, and stride length were calculated and analyzed. Surface EMG signals from erector spinae, rectus abdominis, biceps femoris, rectus femoris, tibialis anterior, and gastrocnemius were sampled at 1000 Hz during waking. The integrated EMG (IEMG) was used to represent the muscle activity. Differences in the measured parameters between NHS and normal shoes were examined with a paired-sample t-test. The 0.05 probability level was used for all tests as the criterion for determining the presence or absence of statistically significant results.

RESULTS AND CONCLUSION: Compared with normal shoes, walking with NHS showed shorter stride cycle time and stride length, yet greater cadence ($p < 0.05$). The maximum dorsiflexion and plantarflexion angles, and the ROM of the ankle joint in walking with NHS were significant larger ($p < 0.05$) than those walking with the normal shoes. Statistical differences were also found in the kinematics of trunk, hip, and knee between two types of shoes. However, those differences in the mean values of the measurements were very small, varying from 0.9 to 1 degree. IEMG analysis showed that biceps femoris, rectus femoris, tibialis anterior, and gastrocnemius had significantly higher activities during stance phase in walking with NHS than those in normal shoes ($p < 0.05$ and 0.01). The results indicate that walking with NHS can enhance muscle activity in the leg, but not in trunk.

REFERENCE:
Benz DA, Stacoff A, Balmer E, Durrer A, Stussi E. (1998). Walking pattern with missing-heel shoes. *The Proceeding of 11th Conference of the ESB*. 8-11.