Leg Length Inequality Case Study
Three-Dimensional Movement Analysis of the Effects of Foot Orthotics and Heel Lift

Scot P. Woodward, M.S., and **Kevin A. Ball**, Ph.D., New York Chiropractic College

Many healthcare professionals evaluate and treat leg length inequality (LLI). Anatomical LLI is produced by significant asymmetry in femoral and/or tibial bone length. Functional LLI describes visual, postural, and/or movement asymmetry but without bone length difference. Much clinical literature exists for LLI and its treatment using foot orthotics and/or heel lifts. However, these topics are controversial. The aims of the present case study were to use advanced three-dimensional (3-D) gait analysis technology to quantify postural and gait alterations produced by treatment using foot orthoses and a heel lift in a subject who exhibits clinically obvious LLI.

METHODS

Procedures were IRB approved. The volunteer male subject (40 years, 1.75 m, 83 kg), an avid runner, periodically experienced mild to moderate right hip pain. The subject wore a black "marker suit" to which 38 small reflective markers were attached at predefined locations. An eight-camera Peak Performance video analysis system was used to record 3-D data (15 s, 120 Hz per trial). Four different footwear conditions were employed: barefoot, athletic shoes, athletic shoes with orthotics (Foot Levelers Inc.), and athletic shoes with a right heel lift (7 mm). Using a parallel foot placement (20 cm between), the subject stood upright, performed low effort knee dipping, and walked at 1.34 m/s upon a treadmill. Kinematic analysis involved conventional 6 degrees of freedom (DOF) rigid body modeling to quantify the motions of the feet, legs, thighs, and pelvis. From these estimates, a novel functional alignment technique generated a subject-specific postural model which was used to create more refined joint-specific and link-segment-specific estimates of 6 DOF body segment dimensions and alignment.

RESULTS

Functional Alignment: Standing Posture

For the barefoot condition, the subject stood in static posture with the pelvis right-rotated 4° and exhibiting 1° of right list. Accordingly, the right hip center was found to be 6 mm lower than the left and the left knee was flexed 9° greater than the right. Calculated estimates of in vivo femoral and tibial lengths showed the left lower limb (hip to ankle center) to be 1.6 cm greater than the right. Analyses of the shoes, orthotics, and right heel lift conditions revealed similar characteristics. However, use of the right heel lift was not directly additive. Knee flexion increased by 3° on the right side.

Functional Alignment: Gait

Measured gait and postural asymmetries included: compensatory adaptation of right pelvic rotation to aid right leg push-off; greater extension of the right hip at push-off; early plantarflexion in the right foot from mid to late stance to functionally increase the right leg; and greater flexion in the left knee to effectively decrease the length of the "longer" left limb. Use of the foot orthoses or the right heel lift provided evidence of desirable compensations, notably increased symmetry in the positioning of the legs. However, the two treatments did not produce the same effects and neither treatment satisfied all theoretically desired compensations.

DISCUSSION

The subject of this case study was previously diagnosed with a suspected anatomical longer left leg. Analysis using functional alignment provides strong support for this diagnosis. Further testing will be conducted to determine if the addition of the right heel lift to the orthotics yields preferable results. While further work will examine the validity and precision of functional alignment, this technique appears quite suitable for measuring subject-specific asymmetries and treatment effects (i.e., foot orthotics, exercise, and manipulation).

ACKNOWLEDGMENTS

The authors would like to acknowledge the ACC Chiroloan Scholarship Program and Foot Levelers Inc.

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