THE EFFECT OF MILD LIMB LENGTH INEQUALITY ON ABLE-BODIED GAIT ASYMMETRY: A PRELIMINARY ANALYSIS

[1]Matthew Kirk Seeley, [1]Jody Clasey, [1]Brian R. Umberger, & [1]Robert Shapiro
[1]University of Kentucky, Lexington, KY, USA
email: mkseel2@uky.edu, web: www.coe.uky.edu/biodynamics/

INTRODUCTION

Gait is one of the most basic of all human movements, but many aspects of gait, such as the causes of bilateral, lower-limb asymmetries, are still not fully understood [1]. Subtle morphological differences have been suggested as one cause of asymmetries [2], but have not been thoroughly investigated. Therefore, the purpose of this study was to investigate the relationship between morphological differences, specifically mild (< 3 cm) limb length inequalities (LLI), and bilateral, lower-limb, mechanical asymmetries during able-bodied gait.

METHODS

Fourteen females and thirteen males participated in this study (Age = 30 ± 6 yrs; Mass = 73.9 ± 16.9 kg; Height = 1.73 ± 0.10 m). Participation included two data collection sessions: 1) limb-length assessment, and 2) gait analysis. All participants signed an informed consent form before participating.

Limb-length was assessed using dual energy x-ray absorbtiometry. Total body scans were performed using a Lunar DPX-IQ bone densitometer. Limb length was calculated by summing femoral and tibial lengths [3]. LLI were quantified by subtracting the left limb length from the right limb length. The absolute value of this calculation served as the measure of LLI.

Gait analysis was performed using a six-camera motion analysis system (60 Hz) and the Cleveland Clinic marker set. Sagittal plane hip, knee, and ankle joint powers, normalized to body mass, were the gait variables of primary interest. Participants walked at a self-selected pace over two embedded force platforms (960 Hz) so that the right and left feet struck separate force platforms during simultaneous gait cycles. Bilateral, lower-limb asymmetry throughout the gait cycle was quantified using the Euclidean distance (ε) formula:

$$\varepsilon = \sqrt{[(X_{R1}-X_{L1})^2 + (X_{R2}-X_{L2})^2 + \ldots + (X_{R100}-X_{L100})^2]} \qquad (1)$$

where X represents the gait variable under consideration; R and L subscripts represent the considered side (left or right); and the numerical subscripts represent the normalized time interval during the gait cycle.

A Pearson's correlation coefficient was used to describe the linearity of the relationships between LLI and gait asymmetries.

RESULTS AND DISCUSSION

Mild LLI were observed (7 ± 7 mm). Using ε as a single measure of joint power asymmetry throughout the entire gait cycle, bilateral asymmetries were observed at the hip (4.84 ± 2.86 W/kg), knee (4.35 ± 2.23 W/kg), and ankle (2.83 ± 1.50 W/kg). However, no significant, linear relationships between LLI and hip power (R^2 = .012), knee power (R^2 = .081), or ankle power (R^2 = .006) were observed (Figure 1). Three other gait variable asymmetries that did result in statistically significant, but weak, linear relationships with LLI were: 1) knee flexion moment (R^2 = .196), 2) ankle abduction moment (R^2 = .158), and 3) ankle flexion angle (R^2 = .183).

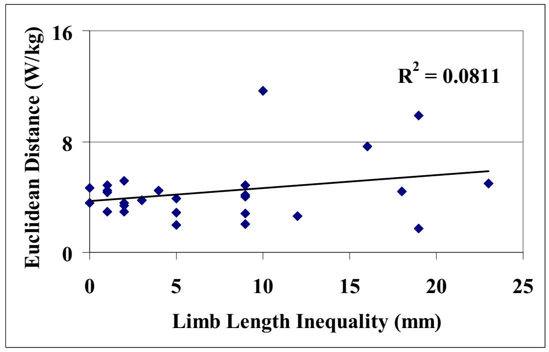

Figure 1: A scatter plot, typical of the plots observed during this study, showing a non-significant, linear relationship between limb length inequality and bilateral, knee joint power asymmetry during able-bodied gait.

Based on the current analysis, there are only weak relationships between mild LLI and bilateral asymmetry during human gait. It is unknown whether a mean LLI closer to our 3 cm threshold might have led to larger gait asymmetries. It is also not clear whether our ε measure is the single best indicator of asymmetry over the gait cycle (as opposed to at a specific point in the cycle). We are currently considering other indicators of asymmetry that might better take into account the whole movement cycle.

CONCLUSIONS

During the present study, only a few weak, linear relationships between LLI and able-bodied gait asymmetry were revealed; no statistically significant, linear relationships were observed between LLI and able-bodied gait asymmetry for the gait variables of primary interest. Further research considering: a) other methods effective in quantifying gait asymmetry; b) variables that resulted in significant correlations during this study; and c) other issues that may contribute to able-bodied gait asymmetry such as footedness, the environment, skill, or neuromuscular factors may also help illuminate this topic.

REFERENCES

1. Sadeghi, H, et al.. *Gait & Posture,* **12,** 34-45, 2000.
2. Subotnick, SI.. *J Orthop Sports Phys Ther* **3,** 11-16, 1981.
3. Durkin, JL, et al.. *J of Biomech* **35,** 1575-1580, 2002.