EVALUATING GAIT SYMMETRY AND LEG DOMINANCE DURING WALKING IN HEALTHY OLDER ADULTS

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SUMMARY

Gait symmetry is commonly used as a marker for gait health. However, research is divided on whether gait symmetry exists in healthy populations. This work evaluates gait symmetry using three measures for leg dominance. Results suggest that functional gait asymmetry is normal in healthy older adults when using leg dominance as defined by the limb producing the greater propulsive force during gait.

INTRODUCTION

Gait symmetry has often been a measure of assessing gait health. Healthy gait is assumed to include lower limb symmetry, whereas gait asymmetry is associated with gait pathology. There is some disagreement amongst researchers regarding whether gait symmetry exists in healthy populations [1]. Sadeghi et al. [2] showed that one limb was more responsible for forward propulsion, whereas the other limb provided support and stability during normal walking, suggesting gait asymmetry exists in healthy populations. In contrast, Seeley et al. [3] reported no difference between limbs when participants walked at self-selected speeds.

The symmetry index (SI) is a determinant for gait symmetry [4,5]. SI is the percent deviation from symmetrical (i.e., 0 equals perfect gait symmetry); mathematically, SI is:

\[ SI = \frac{X_1 - X_2}{0.5(X_1 + X_2)} \times 100 \]

with ‘X’ being the gait parameter of interest, such as loading force. As SI is commonly used to assess recovery of gait (e.g., in gait retraining post-stroke or post unilateral lower extremity injury) the subscript “1” refers to the unaffected or healthy side and “2” refers to the affected side. In studies exploring gait in healthy individuals, some researchers use “1” and “2” as the right and left legs, respectively, with no regard to participant’s leg dominance, whereas others have suggested the subscript “1” should be the dominant leg, which may further show whether gait symmetry exists [3].

Assuming the right leg is the dominant leg may obscure some of the functional properties of the lower limbs [1]. In understanding the effects of functional leg dominance, many clinicians and therapists may be able to provide better rehabilitation and treatment. Therefore, the purpose of this study was to evaluate measures of gait symmetry using three different definitions of leg dominance: leg generating peak loading force, leg generating peak propulsive force, and right leg, in a sample of healthy older adults.

METHODS

This study included older adults between 60 and 75 years of age and a body mass index (BMI) between 20 to 30 kg/m\(^2\), without current foot pain and unilateral foot disorders who were enrolled in the Framingham Foot Study. Limiting the population group by BMI and age would reduce the gait differences that may result from being underweight, which was classified as a BMI of 20 kg/m\(^2\) [6], or obese [7]. The age restriction would reduce age-related differences in gait [8]. All participants signed an approved consent form for participation in this study.

Foot disorders were noted as present or absent by an evaluator trained by a podiatric physician. These disorders included: hallux valgus, edema, plantar fasciitis, callus, corns, hammer toes, claw toes, fat pad atrophy (heel or forefoot), overlapping toes, tailors bunion, Morton’s neuroma, hallux rigidus, and varicocities. Foot pain was assessed by the response to the question “On most days do you have pain, aching or stiffness in either of your feet?”

Plantar pressure and gait kinetic variables were collected using a Matscan system (Tekscan Inc., Boston MA) at a rate of 40 frames per second. The participants were asked to walk barefoot at a self-selected pace across the mat, using the two-step method [9]. There were two gait trials, one for each foot.

Gait speed was determined over a 4m walking path at a self-selected pace [10]. There were two trials for gait speed, with the faster of the two trials being used for this analysis. Participants were subsequently grouped based on their gait speed. The three groups for gait velocity were: less than 0.83m/s (< 0.83m/s walkers), 0.83 to 0.99m/s (0.83 – 0.99m/s walkers), and equal to or greater than 1.0m/s (≥ 1.0m/s walkers). These cut-off values were chosen based on findings relating gait speed as a predictor of disability [11,12].

The SI was used to symmetry, with the parameters of interest including: whole foot maximum force, peak pressure, force-time integral (FTI) and pressure-time integral (PTI). Three definitions of leg dominance (i.e., limb denoting subscript “1” in the SI) were used: 1) leg generating greater loading force, 2) leg generating greater propulsive force, and 3) the right leg.

Data analysis consisted of a Kruskal-Wallis test for categorical data and an analysis of variance (ANOVA) for continuous data. Statistical significance was set at p < 0.05.

RESULTS AND DISCUSSION

There were 459 participants in this analysis (Table 1). There were no significant differences in the demographics between the three walking groups. The gait symmetry between groups was significantly different when the dominant leg was defined as the leg that generated the greater propulsive force (Table 2). Using this definition of leg dominance yielded increasing greater asymmetry in peak pressure (p = 0.007), FTI (p = 0.042) and PTI (p = 0.043) between groups as the gait speed increased, but not in maximum force (p = 0.098). In contrast,
only the FTI was significantly different between groups when leg dominance was defined as the greater loading force (p = 0.038) and as the right leg (p = 0.038), with < 0.83m/s walkers walking more symmetrical than the ≥ 1.0m/s walkers. Our results are similar to Seeley et al. work, which showed when an individual’s gait speed increased, the functional gait asymmetry increased as well.

These results show that in healthy older adult populations, gait symmetry and asymmetry are dependent upon the definition of leg dominance used, which strengthens the case for assessing and reporting leg dominance in gait studies. Furthermore, if leg dominance is not evaluated and the right leg is assumed to be the dominant limb, important functional gait differences between the lower limbs may be lost.

Our results also imply that a healthy gait is dependent on gait symmetry, when leg dominance is defined as the leg with the greater propulsive force. As gait speed can be a predictor of future disability in older adults [10], understanding the mechanisms that promote a healthy gait, which includes gait asymmetry, is imperative. Moreover, future work should explore how leg dominance and functional asymmetry in gait relate to balance, fall risk, and activities of daily living (ADLs) to confirm or refute the benefits of functional asymmetry in the lower limbs. Future research should focus on the investigating effective rehabilitation protocols and strategies to address functional gait asymmetry.

CONCLUSIONS
These results suggest that in healthy older adults, functional gait asymmetry between the lower limbs exists and that older adults with a faster gait have a greater degree of asymmetry when leg dominance is defined as the leg with the greater propulsive force during walking.

ACKNOWLEDGEMENTS
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REFERENCES

Table 1: Participant demographics in the three walking speed groups.

<table>
<thead>
<tr>
<th></th>
<th>&lt; 0.83m/s Walkers (N= 182)</th>
<th>0.83 – 0.99m/s Walkers (N= 183)</th>
<th>≥ 1.0m/s Walkers (N=94)</th>
<th>p-value</th>
</tr>
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<tbody>
<tr>
<td>Age (years)</td>
<td>67.2 ± 4.2</td>
<td>65.6 ± 4.2</td>
<td>65.5 ± 4.3</td>
<td>0.224</td>
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<tr>
<td>Number of Female (%)</td>
<td>101 (55.5)</td>
<td>105 (57.4)</td>
<td>54 (57.5)</td>
<td>0.922</td>
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<tr>
<td>BMI (kg/m²)</td>
<td>26.3 ± 2.6</td>
<td>25.9 ± 2.5</td>
<td>25.9 ± 2.4</td>
<td>0.127</td>
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<tr>
<td>Average Walking Velocity (m/s)</td>
<td>0.69 ± 0.10</td>
<td>0.80 ± 0.46</td>
<td>1.12 ± 0.17</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

Table 2: Symmetry index (SI) for the gait parameters of maximum force (MF) and force-time integral (FTI). SI of peak pressure and pressure-time integral (PTI) are not shown. * = p<0.05 between groups

<table>
<thead>
<tr>
<th></th>
<th>Dominance defined by leg with higher loading force</th>
<th>Dominance defined by leg with the higher propulsive force</th>
<th>Dominance defined as right leg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SI-MF</td>
<td>SI-FTI*</td>
<td>SI-MF*</td>
</tr>
<tr>
<td>&lt; 0.83m/s Walkers</td>
<td>-3.27 ± 12.4</td>
<td>0.61 ± 13.5</td>
<td>0.12 ± 10.2</td>
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<tr>
<td>0.83 – 0.99m/s Walkers</td>
<td>-0.13 ± 18.6</td>
<td>3.33 ± 11.6</td>
<td>-0.34 ± 15.6</td>
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<tr>
<td>≥ 1.0m/s Walkers</td>
<td>-2.35 ± 6.8</td>
<td>5.07 ± 13.3</td>
<td>4.49 ± 5.7</td>
</tr>
</tbody>
</table>

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