INTRODUCTION

Falls are a significant risk factor during pregnancy, as over 27% of women fall while pregnant [1, 2]. Falls are a leading cause of trauma-related hospital admissions during pregnancy [3]. Approximately 40% of the falls happen during stair locomotion [1, 2]. Additionally, evidence indicates that pregnant women who fall may have altered neuromuscular control compared to pregnant non-fallers and non-pregnant controls [4, 6].

Ground reaction forces (GRFs) during gait [5, 6] and stair locomotion [7] have been reported for pregnant women. No significant differences in GRFs were noted during gait for women during pregnancy and post-partum [5] or between women in their 2nd and 3rd trimesters and non-pregnant controls [6]. However, the mediolateral (ML) position of the center of pressure (COP) during the stance phase of gait is shifted laterally during pregnancy [5]. Pregnant fallers in their 3rd trimester display a greater ML excursion of the COP during stance than pregnant non-fallers and controls [6]. During stair ascent, women in their 3rd trimester demonstrate greater medial and vertical impulses, or area under the GRF curve [7]. Additionally, compared to non-pregnant women, pregnant women in the latter two trimesters display a smaller impact peak and loading rate of the vertical GRF [7].

This study examined GRFs during stair ascent in pregnant fallers, pregnant non-fallers, and non-pregnant controls. We hypothesized that pregnant fallers would demonstrate greater ML GRF magnitudes as well as greater ML excursion of the COP compared to the pregnant non-fallers and non-pregnant control subjects.

METHODS

Forty one pregnant women (age: 29.5±4.9 yrs, hgt: 1.7±0.7 m, 2nd tri. mass: 74.7±12.1 kg, 3rd tri. mass: 81.6±11.0 kg) and 40 non-pregnant controls (age: 26.5±6.4 yrs, hgt: 1.7±0.6 m, mass: 66.0±8.9 kg) participated. Data were collected on the pregnant women in the middle of their 2nd and 3rd trimesters and on the control women in the week following menses.

Informed consent was obtained during the subjects’ first visit. At each visit, pregnant subjects were surveyed about their history of falls while pregnant. A fall was defined as a loss of balance such that another part of the body other than a foot touched the ground. Fifteen pregnant subjects were classified as ‘fallers’ by having at least one fall and 14 as ‘non-fallers’. Twelve pregnant subjects withdrew from the study prior to their 3rd trimester visit.

Subjects walked at their freely chosen speeds up a four-step staircase during stair ascent. A force plate imbedded in the second stair, but structurally independent of the staircase, was used to collect GRF data (1080 Hz). Kinematic data (120 Hz) were collected from a marker placed on the lumbar spine to determine ascent velocity. Three trials were collected from each subject. All GRF variables were normalized to body weight.

A one-factor ANCOVA was performed between groups (control, pregnant faller, pregnant non-faller) on each of these ML GRF variables: max medial force, time to max medial force, medial impulse, max lateral force, time to max lateral force, and lateral impulse. Stair ascent velocity was a covariate in each statistical analysis. Anterioposterior (AP) GRF variables were also analyzed using ANCOVA: max braking force, time to max braking force,
braking impulse, max propulsive force, time to max propulsive force, and propulsive impulse. An ANCOVA was performed on each of these vertical GRF variables: impact peak, time to impact peak, loading rate, active peak, time to active peak, and impulse. (Bonferroni-corrected α = 0.008) An ANCOVA was performed for the ML excursion of the COP during stance and stance time (Bonferroni-corrected α = 0.025). Tukey post-hoc tests were performed when appropriate (α = 0.05).

RESULTS AND DISCUSSION

In the ML GRFs, the max medial force was larger in the pregnant fallers compared to the pregnant non-fallers and controls. In the AP GRFs, pregnant fallers displayed a longer time to the max braking force than the pregnant non-fallers and a greater braking impulse than the pregnant non-fallers and controls. Variables that were significantly different between the groups are shown in Table 1. No differences were noted between the pregnant non-fallers and the controls, nor were any differences noted between groups in the vertical GRFs. Additionally, neither stance time (p = 0.681) nor the ML excursion of the COP during stance (p = 0.743) were different between groups. In the variables that were significant between groups, ascent velocity was not a significant factor.

While not statistically significant, the peak lateral force tended (p = 0.072) to be less in the pregnant fallers (0.017±0.004 BW) than in the pregnant non-fallers (0.026±0.004 BW) and the controls (0.024±0.004 BW). Similarly, the medial GRF impulse tended (p = 0.072) to be larger in the pregnant fallers (-0.035±0.001 BW s) than in the pregnant non-fallers (-0.031±0.001 BW s) and controls (-0.028±0.001 BW s).

Several differences were noted between pregnant fallers and non-fallers, with fewer differences noted between pregnant non-fallers and controls. Pregnant fallers may have altered neuromuscular control that increases their risk of falling. In particular, the differences in the ML direction in pregnant fallers may be related to changes in frontal plane control.

If biomechanical alterations were noted in all of the pregnant women, it could be assumed that the falls could have happened purely by the chance encounter of a risk factor for falling, such as a slippery floor, uneven sidewalk, object on the floor, etc. However, pregnant fallers and non-fallers displayed differences in GRFs in our laboratory setting. Additional differences between these pregnant fallers and non-fallers were also noted in other gait and postural stability parameters [4, 6].

CONCLUSION

Pregnant fallers demonstrated alterations in GRFs during stair ascent compared to pregnant non-fallers and controls. These differences may be indicative of poor control and increased instability.

REFERENCES

2. Dunning K et al. Matern Child Health J. 14; 720-5, 2010

ACKNOWLEDGEMENTS

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Table 1: GRF variables which were different between pregnant fallers (PF, n = 15), pregnant non-fallers (PNF, n = 14) and controls (C, n = 40). Data shown are mean (standard error).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control</th>
<th>Pregnant Non-Fallers</th>
<th>Pregnant Fallers</th>
<th>p-value</th>
<th>Post-hoc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to Braking Peak (s)</td>
<td>0.137 (0.013)</td>
<td>0.107 (0.014)</td>
<td>0.171 (0.013)</td>
<td>0.001</td>
<td>PF &gt; PNF</td>
</tr>
<tr>
<td>Braking Impulse (BW s)</td>
<td>-0.006 (0.001)</td>
<td>-0.006 (0.001)</td>
<td>-0.008 (0.001)</td>
<td>0.002</td>
<td>PF &gt; PNF, C</td>
</tr>
<tr>
<td>Max Medial Force (BW)</td>
<td>-0.083 (0.002)</td>
<td>-0.082 (0.002)</td>
<td>-0.091 (0.002)</td>
<td>0.008</td>
<td>PF &gt; PNF, C</td>
</tr>
</tbody>
</table>