SEX DIFFERENCES IN LEVEL WALKING VERTICAL GROUND REACTION FORCE CHARACTERISTICS IN ADULTS WITH MEDIAL KNEE OSTEOARTHRITIS


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INTRODUCTION

Women are twice as likely as men to suffer from knee osteoarthritis (OA), and they experience greater pain and disability over their lifetime from the chronic disease [1]. The interplay of biomechanics and the pathophysiology of knee OA have been investigated for insight into the progression of the disease and the increased incidence and prevalence in women [2]. The relationship between knee loading during walking and medial knee OA has been previously investigated, but it is unclear if sex differences exist. The purpose of this study was to investigate the effects of sex differences in the vertical ground reaction force characteristics of adults with prevalent knee OA.

METHODS

The study sample consisted of 306 subjects with knee OA who were consented for participation. While 99% of the subjects had bilateral knee OA and 87% of knees had multi-compartment involvement, this analysis excluded those with no medial compartment OA and reduced the sample size to 294 subjects (221 women and 73 men, Table 1).

Bilateral weight-bearing radiographic examinations were performed to determine the OA grade according to the Kellgren and Lawrence system. Ground reaction forces were measured with force plates during gait analysis of level walking. The maximum force of the vertical ground reaction force was identified in addition to the timing of the force during the gait cycle (Fig 1). The timing of the maximum force was classified as either during the loading response phase or terminal stance. The heelstrike transient loading rate was calculated as the slope from heelstrike to the heelstrike transient peak (Fig 1). The maximum force and loading rate were normalized to body weight.

T-tests were used to test for sex differences in demographics and gait variables (Table 1). Logistic regression was used to test the effects of sex on the timing of the maximum vertical ground reaction force while controlling for medial knee OA grade. Linear regression was used to adjust the effects of sex on the maximum force and loading rate to the medial knee OA grade.

Table 1. Subject demographics and gait variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Women mean (95% CI)</th>
<th>Men mean (95% CI)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>221</td>
<td>73</td>
<td></td>
</tr>
<tr>
<td>Age (yrs)</td>
<td>56.5 (55.1-57.9)</td>
<td>59.2 (56.6-61.6)</td>
<td>0.06</td>
</tr>
<tr>
<td>BMI (kg/m^2)</td>
<td>32.3 (31.4-33.2)</td>
<td>30.4 (29.0-31.6)</td>
<td>0.02*</td>
</tr>
<tr>
<td>Velocity (cm/s)</td>
<td>114.6 (112.8-116.5)</td>
<td>118.1 (114.8-121.5)</td>
<td>0.07</td>
</tr>
<tr>
<td>Cadence (steps/min)</td>
<td>114.2 (113.0-115.4)</td>
<td>109.3 (107.2-111.4)</td>
<td>0.00*</td>
</tr>
<tr>
<td>Step width (cm)</td>
<td>10.5 (10.2-10.9)</td>
<td>11.1 (10.5-11.8)</td>
<td>0.09</td>
</tr>
</tbody>
</table>

Figure 1. Female and male representative vertical ground reaction force plots over the gait cycle
RESULTS AND DISCUSSION

Women had a significantly higher BMI and cadence than the men (Table 1). The majority of women (73%) experienced a maximum force during terminal stance while the majority of men (60%) applied their maximum force during the initial loading response after heelstrike (p<0.0001, Fig 1). There was no effect of OA grade on maximum force timing (p=0.85). Similar trends have been shown in men and women without lower extremity joint pathology over the lifespan [3] suggesting that the sexually dimorphic patterns in the vertical ground reaction force may be a risk factor for knee OA development.

There were no effects of sex on the maximum vertical ground reaction force (p=0.68, Fig 2) or the heelstrike transient loading rate (p=0.88, Fig 3). There was a significant effect of KL OA grade with a reduction in the loading magnitude (p=0.0004) and rate (p=0.02) as the severity increased (Figs 2 & 3). Previous hypotheses that an increased heelstrike transient loading rate may have detrimental effects on the cartilage in women are not supported by the results of this study.

CONCLUSIONS

The majority of women walked with a maximum vertical ground reaction force in terminal stance while the majority of men walked with a maximum vertical load during the first peak of the loading response. There were no differences between men and women in the heelstrike transient loading rate and the magnitude of the maximum vertical ground reaction force. Further investigation is warranted in sex differences of loading during walking to identify characteristics that might put women at greater risk of developing medial knee OA.

REFERENCES


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