INTRODUCTION

Multifocal (MfL) lens glasses, a commonly prescribed solution to presbyopia, have been shown to increase fall risk [1]. One way in which MfL glasses may cause falls is by distorting the apparent location and shape of steps (Fig. 1). Differences in toe clearance and approach step distance occur when wearing MfL glasses compared with single lens (SL) glasses [2]. While MfL glasses are known to modify gait parameters during step-up (e.g. approach step distance, toe clearance, step distance) [2], the effects of these glasses during step down is not as well understood. When stepping down from a standing posture, participants respond to blurred vision with caution by slowing stepping speed and reducing weight transfer indicating that visual feedback is important to stepping down [3]. Additionally, there is a paucity of research on novice wearers, who may be at the most risk of falling while they are learning to adapt to the distortion. The participant pools of other research have been primarily been elderly population [2-3] and therefore the effects of aging have not been teased out from the effects of the lenses alone. This study aims to examine the effects of multifocal lens glasses, age and experience during step up and step down tasks.

METHODS

Fifteen younger novice (YN: 24.3 (18-28) y.o., 10 F, 5M), seven older novice (ON: 52.4 (48-56) y.o., 4F, 3M) and five older experienced MfL glasses wearers (OE: 51 (45-58) y.o., 2F, 3M) were recruited for a single 1.5 hour testing session. “Younger” and “older” terms refer to the relative ages of the participants and not age categories. Novice wearers eye sight was corrected with contact lenses if necessary. The protocol was approved by the UWM Institutional Review Board. Participants experienced three trials for five walking conditions in random order: level walking, walking up a ramp then down a 75 mm step, walking up a ramp then down a 150 mm step, a 75 mm step up then a ramp down and a 150 mm step up then a ramp down. Participants did this set of trials while wearing both SL and progressive MfL glasses in random order. MfL glasses for novice wearers had no upper lens region correction, and an “add” of +2.75 diopters in the lower region for the novice wearers. Experienced wearers wore glasses with their current prescription for the MfL condition and single lens glasses with their upper prescription for the SL condition.

Toe clearance during step up and heel clearance during step down were calculated as the minimum distance between the edge of the step and a marker placed on the front of the toe and back of the heel, respectively. In addition, the distance between a marker placed on the toe of the non-stepping leg, a marker placed at the heel of the stepping leg and the step were also calculated.

The effects of the independent variables: lens type, step height, group (YN, ON, or OE) and the first order interactions; were evaluated on the dependent variables: toe clearance during step up and heel clearance during step down. Correlation analyses
between step up toe clearance and step down heel clearance were performed with the trailing leg toe to step distance and the stepping leg heel to step distance. This analysis aimed to identify if changes in toe clearance might be due to step placement.

RESULTS AND DISCUSSION

Toe clearance during step up was greater in the MfL glasses condition than the SL condition (p<0.001). The type of lens affected the different participants group differently (lens * group effect: p<0.01). Experienced MfL wearers demonstrated little difference in toe clearance between the single lens and MfL glasses, while both the other novice groups increased toe clearance during the MfL condition as opposed to the single lens (Table 1). Both the distance from the toe to the step of the non-stepping leg (p<0.001, R²=0.15) and the heel to the step of the stepping leg (p<0.001, R² = 0.06) were significantly correlated with the toe clearance.

Heel clearance during step down was higher with single lens glasses than MfL glasses (p<0.05, Table 1). Other significant effects for heel clearance included step height (more clearance for high step height, p<0.05), group (older novice group had lowest heel clearance, p<0.05), group * height interaction (older experienced had higher clearance with the low step than high step while other groups had higher heel clearance with the high step, p<0.01). The heel clearance during step down was correlated with the toe to step distance of the non-stepping leg (p<0.01, R² = 0.06) and the heel to step distance of the stepping leg (p<0.001, R² = 0.10).

Novice participants (both younger and older) responded to MfL glasses with large increases in toe clearance when stepping up, while older experienced wearers used a similar stepping technique for both types of glasses. This indicates that experienced wearers have adapted to the MfL glasses and no longer alter their stepping pattern when wearing MfL glasses. Increase in toe clearance may be a compensatory response by novice users to prevent tripping as they first start to learn how to navigate using the glasses. Heel clearance, however, was found to decrease during MfL glasses compared with single lens glasses during step down, indicating a greater potential for tripping. No interaction effect was observed between the glasses worn and the group during step down, indicating that the same adaptation may not be present during step down task. Because of the extra burden of absorbing the potential energy during a step down task, an increase in trip risk during step down (as indicated by lower heel clearance) may be responsible for severe falls. Step placement seemed to contribute partially to the heel and toe clearance.

Novice wearers may automatically compensate during step up by increasing toe clearance thus reducing the need for interventions for that task. Yet stepping down may be a more challenging activity and it is unclear what, if any, protective adaptations are used by novice wearers. Therefore, future research may wish to determine if stepping down variables such as heel clearance, approach step distance or stepping foot placement are associated with fall risk and if interventions can improve these outcomes. In addition, older novice wearers responded to MfL glasses similarly to younger wearers, indicating that convenience sampling of young participants may be an appropriate group to pilot test interventions. Because the “older” group was relatively young and healthy, the results would likely vary for higher age groups including elderly adults.

REFERENCES


Table 1: Toe clearance and heel clearance mean values (standard deviation).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Lens</th>
<th>Older Experienced</th>
<th>Older Novice</th>
<th>Younger Novice</th>
<th>Lens</th>
<th>Group</th>
<th>Lens x Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toe Clearance</td>
<td>MfL</td>
<td>102.3 (26.2)</td>
<td>131.1 (28.8)</td>
<td>117.6 (33.6)</td>
<td>p&lt;0.001</td>
<td></td>
<td>p&lt;0.01</td>
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<tr>
<td>Step Up (mm)</td>
<td>SL</td>
<td>103.7 (20.1)</td>
<td>108.9 (22.6)</td>
<td>92.0 (26.8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heel Clearance</td>
<td>MfL</td>
<td>82.5 (25.8)</td>
<td>65.7 (23.0)</td>
<td>89.8 (21.8)</td>
<td>p&lt;0.05</td>
<td>p&lt;0.05</td>
<td></td>
</tr>
<tr>
<td>Step Down (mm)</td>
<td>SL</td>
<td>89.4 (34.9)</td>
<td>72.1 (16.2)</td>
<td>90.7 (26.3)</td>
<td></td>
<td></td>
<td></td>
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