Comparison of Pelvic and Knee Kinematics During Overground and Treadmill Walking with Change in Optic Flow

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Abstract

The integration of optic flow has previously been used to engage the patients who are undergoing physical therapy. A stereoscopic display, used to display optic flow, gives patients the option to look at the projection of a moving virtual environment instead of just a plain wall. The purpose of this research is to determine pelvic and knee kinematic data in all planes of motion using a stereoscopic display during gait over four different walking conditions. Pelvic and knee range of motion (ROM) were assessed over the four walking conditions. Statistical differences (P<0.05) between overground and overground with optic flow were evident for pelvic rotation and pelvic tilt, whereas the condition of treadmill and treadmill with optic flow showed statistical differences in pelvic obliquity and tilt. For knee kinematics, statistical differences were evident for knee extension and flexion between treadmill walking and overground walking. Moreover, incorporating the stereoscopic display shows no significant difference between overground walking and treadmill walking. The results show a positive trend that with further research therapeutic practices could be promising for using a stereoscopic display as an option to engage clients and make therapy sessions more effective.

Introduction

To determine whether overground walking and treadmill walking produced similar dynamic analysis with introduction of optic flow, differences in pelvic and knee kinematic were examined. Previous studies have focused on joint kinematics on the hip, knee and ankle only, although there are a few studies that have also examined the pelvic kinematics [1-4]. Major factors that create differences in overground and treadmill walking are surface compliance, variations in belt speed, and unfamiliarity with walking on a treadmill [1]. Literature suggests that minor gait differences do exist between treadmill and overground walking, however these differences have not been significant enough in order to treat them as having clinical significance. Another aspect that has been previously studied when comparing treadmill and overground walking is the effect of optic flow in reference to walking speed [3,4]. Optic flow is a typical pattern of visual motion generated at the eye as the person moves through the environment. For this purpose, it is important to further study gait differences between treadmill and overground walking and the effects of optic flow. In this study the speed of the optic flow was set the same for both walking conditions.

Methods

Ten healthy subjects, 5 male and 5 female, between the ages of 18 and 35 were enrolled in this study. The data set is a subcomponent of the study with 7 subjects. A 10-camera Oqus 300 1.3 MP infrared motion capture system (Qualisys, Gothenburg, Sweden) was used to capture kinematic data. The research team developed a code written in MATLAB (Natick, MA) to process outcomes. An Oculus Rift VR head mount display (Irvine, California) was used to display a 3-D environment that was staged using Unity SDK software.

• 8 Passive Reflective Makers
  • Pelvis: Anterior/Posterior/iliac crest
  • Knee: Lateral/medial, left/right knee

• Four Test Conditions
  • Over Ground
  • Over Ground with Optic Flow
  • Treadmill
  • Treadmill with Optic Flow

Figure 1: Subject on treadmill with occlus, a total of 36 markers were used but only 8 were used for outcome calculations **The optic flow speed, the overground speed converted from m/s/hr to Unity Speed (0/03), was set at the beginning of each optic flow trial.

Table 1: Pelvic and knee range of motion (ROM) for overground and treadmill walking. The ROM data shown are mean values (degrees) with standard deviations. Double asterisk, overground values are statistically different from the treadmill values for both conditions. Overground or treadmill values with an single asterisk are statistically different than the same condition with optic flow.

<table>
<thead>
<tr>
<th>Pelvis</th>
<th>Tilt</th>
<th>Obliquity</th>
<th>Rotation</th>
<th>Flexion/Extension</th>
<th>Abduction/Adduction</th>
<th>Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OG</strong></td>
<td>6.22 (±1.39)</td>
<td>9.45 (±1.57)</td>
<td>10.73 (±2.78)*</td>
<td>64.98 (±6.21)</td>
<td>17.53 (±5.18)</td>
<td>22.55 (±4.57)</td>
</tr>
<tr>
<td><strong>OG w/OF</strong></td>
<td>5.59 (±1.61)</td>
<td>7.71 (±2.77)</td>
<td>7.51 (±3.24)</td>
<td>66.34 (±2.22)</td>
<td>16.60 (±2.57)</td>
<td>21.96 (±1.76)</td>
</tr>
<tr>
<td><strong>TM</strong></td>
<td>4.69 (±1.42)*</td>
<td>10.57 (±1.81)*</td>
<td>9.38 (±3.73)</td>
<td>65.92 (±1.30)</td>
<td>22.06 (±4.90)</td>
<td>23.22 (±3.89)</td>
</tr>
<tr>
<td><strong>TM w/OF</strong></td>
<td>5.80 (±1.00)</td>
<td>11.66 (±1.78)**</td>
<td>5.55 (±6.21)</td>
<td>64.26 (±2.29)</td>
<td>21.22 (±5.23)</td>
<td>21.78 (±4.17)</td>
</tr>
</tbody>
</table>

Conclusion

As a result of this study, there is a better understanding of the effect of using a head mount display with optic flow and the differences between overground and treadmill walking. Differences in pelvic and knee kinematics for the four walking conditions were small enough to not be considered of having clinical significance. Although subjects drifted to the left or right when walking overground with the head mount display, due to the fact that optic flow may change how they integrate sensory information when walking [4]. This study suggests that treadmill walking with optic flow in a virtual environment should be similar enough to overground walking that it should not alter gait parameters.

Recommendations for the future include studying temporal data such as step width, step length, and speed which would give more information regarding the difference between the walking conditions and the incorporation of optic flow. To further expand on the idea that optic flow does not change gait parameters, more subjects would need to be enrolled in the study.

References


Results

Figure 2: Pelvic ROM values (mean and standard deviation) in all four walking conditions. The asterisk indicates statistical difference (P<0.05).

Figure 3: Knee ROM values (mean and standard deviations) in all four walking conditions.

3-D Virtual Environment

The environment created in Unity UDK represent a long half way, seen in Figure 4, was chosen to simulate a walking environment similar to lab room. The simplicity makes it easier for first time users to adjust to 360° viewing experience.

Figure 4: A screen shot of the UDK Game created in UDK edited by Dr. Derek Lura.

Discussion

T-tests two sample assuming unequal variances were used to compare the following conditions: overground vs. treadmill and overground with optic flow vs. treadmill with optic flow. The reported values of pelvic and knee flexion/extension tilt and rotation were graphically shown in Figures 2 and 2. Pelvic tilt and rotation showed statistical differences (P<0.05) between overground and overground with optic flow. Pelvic tilt and obliquity also suggested evidence of statistical difference (P<0.05) between treadmill and treadmill with optic flow. Table 1 illustrates the averages ROM for the pelvic and knee angles in the three planes of motion.

When overground vs. treadmill walking was compared, no statistical differences were found for pelvic and knee ROM. Pelvic obliquity showed statistical difference between overground with optic flow and treadmill walking with optic flow. This trend may suggest that there are more gait differences when walking in a virtual environment. The speed between overground and overground with optic flow varies between subject for 7mi/hr:102.

For the knee kinematics, the trend suggest an opposite effect, it decreases ROM with the incorporation of optic flow in both overground and treadmill walking. The pelvic kinematics, the trend suggests that the incorporation of optic flow in the treadmill walking condition increases ROM, whereas it decreases for the overground walking condition.