Balancing for differences in gross motor function between youth with CP at GMFCS levels II and III while ‘Exergaming’

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Background

Cerebral Palsy (CP) & Exergames
- In the Liberi exercise video game (exergame) players pedal to move their avatar, helping children engage in moderate cardiovascular exercise and socializing with their peers.1,2
- Ability varies greatly in CP, while some walk unassisted other require mobility devices (GMFCS level II v III).3
- Game balancing algorithms may help those with different gross motor abilities to socialize, exercise and play successfully together.1
- Balancing algorithms have not been evaluated for youth with Cerebral Palsy and GMFCS levels II and III in the Liberi Exergame.

Methods & Analyses

Participants:
- Diagnosis of CR at GMFCS level II or III, aged 10-16, participating in 2-week Sport FIT & Recreation Camp at Holland Bloordview

Protocol:
- 30 minutes of exergaming / day for 6 days

Outcome Measures:
- 1. Game Success: players average score normalized to highest score
- 2. Time >40% HRR: time above 40% HRR, total playtime.
- 3. Enjoyment: mean Intrinsic Motivation Inventory (IMI)

Primary Statistical Analysis:
- Two way mixed repeated measures ANOVA for each outcome measure evaluated differences between TC and other algorithms by GMFCS level.

Research Question

How well does the TC algorithm balance: (1) game success, (2) percent of time above 40% HRR, and (3) enjoyment compared to GB and OSFA algorithms between youth with CP at GMFCS levels II and III in the Liberi Exergame?

Table 1: Participant Characteristics

<table>
<thead>
<tr>
<th>GMFCS</th>
<th>II (4)</th>
<th>III (6)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender M/F</td>
<td>3/1</td>
<td>2/4</td>
<td>5/5</td>
</tr>
<tr>
<td>Age Mean (SD)</td>
<td>12.5 ± 2.4</td>
<td>12.3 ± 1.5</td>
<td>12.4 ± 1.7</td>
</tr>
</tbody>
</table>

Discussion

- Participants at GMFCS level II had similar game success but spent more time above 40% HRR compared to those at level III. TC trended towards better balancing for game success and had comparable enjoyment between GMFCS levels but poorest balance in percent of time above 40% HRR. TC and OSFA helped players who pedaled slower remain competitive (more similar game success).

Conclusion

- TC shows promise in balancing game success and enjoyment but improvements are needed to balance between GMFCS levels for cardiovascular exercise.
- By accounting for player ability, we may foster more inclusive gaming that facilitates cardiovascular activity and social engagement for people with different abilities.

Results

Figure 1: CP Exergaming. Pedaling the recumbent bicycle (left) moves the player’s avatar in the game (right)

Figure 2: Mean Game Success

<table>
<thead>
<tr>
<th>Normalized Game Success (%)</th>
<th>TC</th>
<th>GB</th>
<th>OSFA</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1,8 = 0.74, p = 0.41</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>F2,3,2, p = 0.11</td>
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</tbody>
</table>

Figure 3: Mean Time >40% HRR

<table>
<thead>
<tr>
<th>Percent playtime</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
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</thead>
<tbody>
<tr>
<td>TC (Algorithm)</td>
<td>74</td>
<td>27</td>
<td>11</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>GB (Algorithm)</td>
<td>38</td>
<td>27</td>
<td>15</td>
<td>18</td>
<td>24</td>
<td>22</td>
<td>19</td>
<td>16</td>
<td>12</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>OSFA (Algorithm)</td>
<td>45</td>
<td>65</td>
<td>21</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
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Figure 4: Mean IMI Enjoyment Score

<table>
<thead>
<tr>
<th>Mean Interest/Enjoyment Score</th>
<th>TC</th>
<th>GB</th>
<th>OSFA</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1,8 = 1.7, p = 0.19</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>F2,0,06, p = 0.80</td>
<td>5</td>
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Limitations

- Accuracy of ‘threshold cadence’
- If inaccurate, participants may need to work harder/less hard with TC algorithm to reach max speed and stay motivated.
- Multiple factors influencing game success and in turn may impact exercise benefit and participation:

Future Direction

- Improving game balancing to facilitate heart rate
  - Ensuring accurate ‘threshold cadence’ based on individual heart rate and physical ability.
  - The GMFR may be helpful in developing balancing algorithms based on ability instead of using heart rate alone.
  - GMFR scores as maybe an accessible and standardized metric to scale avatar speed to pedaling ability and drive heart rate.
- Expand exergame balancing algorithms to test for a wider disparity in gross motor abilities.
- Balancing for factors beyond gross motor function (i.e. differences in fine motor function).

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- All authors contributed to the study design, methodology, data collection and analysis, and preparation of the manuscript

References