Movement Variability During Walking and Elliptical Exercise for Individuals with Chronic Severe Traumatic Brain Injuries

Thad W. Buster, MS; Judith M. Burnfield, PT, PhD
Movement and Neurosciences Center, Madonna Rehabilitation Hospital, Lincoln, NE, USA

Introduction
After severe traumatic brain injury (TBI), it is important to utilize movement strategies with complex variability in order to encourage recovery that is highly adaptable. While elliptical machines are being used more widely in practice, it is unclear as to how their movement variability will compare to walking on a treadmill.

Methods

Kinematics:
- Qualysis Motion Analysis System (12 Osiris infrared cameras; 120 Hz)
- Foot-Floor Contact Patterns (compression-closing footswitches; 120 Hz)

Instrumentation
Exercise equipment
- Treadmill (Life Fitness, 97Ti)
- Elliptical (TRUE, TSXa)

Procedures
Session 1 and 2: Familiarization
- Participants walked on treadmill and elliptical trained for 5 minutes after comfortable speed was determined

Session 1 and 2: Data Collection
- 3D lower extremity kinematic data recorded for one minute during treadmill walking and elliptical training
- Equipment order randomized

Data Analysis
- Maximum Lyapunov exponents (LyE) calculated from 30 consecutive strides of joint motion time series at the hip, knee, and ankle for each condition.

Statistical Analysis
- Independent t-tests evaluated differences between walking and elliptical training.

Results
Three-dimensional state space plots for 30 consecutive strides. Note: less overlap indicates greater divergence (i.e., larger maximum LyE values).

Table 1. Comparison of Hip, Knee, & Ankle Maximum LyE for Walking & Elliptical Exercise

<table>
<thead>
<tr>
<th>Joint</th>
<th>Maximum LyE Walking</th>
<th>Maximum LyE Elliptical</th>
<th>Sig. level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip</td>
<td>0.072 (0.028)</td>
<td>0.067 (0.032)</td>
<td>P = 0.462</td>
</tr>
<tr>
<td>Knee</td>
<td>0.054 (0.013)</td>
<td>0.059 (0.009)</td>
<td>P = 0.332</td>
</tr>
<tr>
<td>Ankle</td>
<td>0.084 (0.013)</td>
<td>0.110 (0.030)</td>
<td>P = 0.024</td>
</tr>
</tbody>
</table>

Conclusions
Contrary to our hypothesis, elliptical exercise machines do not constrain variability. The complexity of the movement pattern variability is actually enhanced at the ankle joint. Elliptical exercise should be considered if incorporating complex variability is a rehabilitation goal.

References

Acknowledgements
The contents of this research report were developed under the Bill Kuby Research Scholarship Grant, awarded to Buster TW.