INTRODUCTION AND OBJECTIVE

- About 795,000 people experience strokes in the US, annually [1]. Many stroke victims suffer from hand disabilities such as weakened grip strength, lack of muscle coordination, and hand spasticity [2, 3].
- Develop a portable and compact gyroscopic device hand rehabilitation, named Gymball.
- Conduct pilot study to validate the device’s design and assess the prospect of using it for therapy.
- Study whether:
  - the gyroscopic torque, generated by the device, can induce passive movement of the user’s hand.
  - the produced hand motion can be controlled.
- There are two kinds of therapies that can be implemented with such a device:
  - One involving synchronization of the hand movement with the generated torque – leading to hand muscle relaxation.
  - Another requiring the user to resist the torque – potentially increasing hand muscle strength and coordination [4].

DESIGN

- The HRD is a fully-actuated rotor-gimbal assembly that, when actuated, imposes a gyroscopic torque on the user’s hand.

FEASIBILITY STUDY

- A healthy 25-year-old male was recruited for this study. The subject was asked to relax the hand while exerting minimal effort to hold the Gymball.
- The experiment involved six different sets of operating conditions which have been tabulated in Table 1. Two trials were conducted for each set.

Table 1: Sets of operating conditions: the velocity of rotor (R) and gimbal (G) in rad/s

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>150</td>
<td>150</td>
<td>−150</td>
<td>−150</td>
<td>150</td>
<td>−150</td>
</tr>
<tr>
<td>G</td>
<td>37</td>
<td>−37</td>
<td>37</td>
<td>−37</td>
<td>37 sin(0.63$t$)</td>
<td>37 sin(0.63$t$)</td>
</tr>
</tbody>
</table>

OBSERVATIONS

- The observed hand motion imposed by the Gymball was considerably higher about the roll axis (pro/supination) than the pitch (radial deviation).
- The supinated angular displacements were greater in magnitude than the pronated ones.
- Finally, the direction of the hand’s circumduction is dictated by the direction of the gimbal’s motion.

CONCLUSION

- The Gymball can be currently used for generating motions, about the wrist, of at least 10°.
- Changes in the gimbal’s rotational direction demands the same of the user’s hand.

FUTURE WORK

- Develop a controller to generate several hand motion patterns.
- Conduct studies with stroke patients (where tools such as Fugl Meyer and Modified Ashworth Scale will be used to judge the efficacy of the device).
- Measure the contact forces between the hand and the device.
- Increase torque generated by increasing rotor inertia and speed.

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REFERENCES