The Human Engineering Research Laboratories
• Numbers
  – Wheelchair users in the US: ~ 2.8 million people (2002 census)
  – Wheelchair users in the world: ~ 67 million

• Heart disease and CVA are prominent causes of morbidity and mortality

• Exercise decreases the risk of heart disease and CVA
• Hurdles for wheelchair users $^{1,2}$
  – relatively small muscle mass available
  – deficient cardiovascular reflex responses
  – inactivity of the venous muscle pump

Engaging users to be actively involved in exercise.
GAME Wheels & GAME Cycle

Shirley Fitzgerald, Rory Cooper, Michael Boninger, Erica Authier, Erin Mishey, Songfeng Guo, Garrett Grindle, Annmarie Kelleher, Rosemarie Cooper, Tom O’ Connor, Beth Ann Kaminski, Mike Dvorznak, Sean Reeves, Three Rivers Holding, Inc
GAME Wheels

GOAL

To motivate people who use wheelchairs to exercise, thus increasing activity level and overall quality of life
Need for Speed II, Power Boat Racer, Doom
GAMEWheels Trainer - Clinic Version
GAME Wheels Trainer - Home Version
Focus group
Teach the use of the system
6 subjects trained on both versions

Results
Low frustration in the learning process on both systems
Overall impressions on both – ‘fun’
Home trainer viewed more favorably
Kinetic and physiological analysis of the Gamewheels system
Conclusions $^{3,4,5}$

- **GAME$^\text{Wheels}$** system indicate that increased physiological responses may be achieved with game play.
- Both oxygen consumption and ventilation rate were higher with game play
- Using their muscles to play or control the game leading to a cardiovascular response, which can help maintain or increase their cardiovascular fitness level.
The GAME\textsuperscript{cycle} exercise system: Comparison with standard ergometry

Does . . .

- The GAME\textsuperscript{Cycle} elicit an exercise effect?
- It compare to the standard arm ergometer, in terms of these effects?
Methods

• Two trials performed
  – Randomized
  – Two hours apart

• Resting heart rate
  – Maximum heart rate calculated
  – Range of 60-80% of maximum defined
  – Subjects asked to stay within that zone

• Same resistance used for both trials

• Metabolic information collected
  – VO2, VCO2

• Rating of perceived exertion
Results

• 13 subjects
  – 4: C5-C6
  – 4: T6-T8
  – 5: T10 or below

• 92% Male

• 41 ± 9.4 years old

• 9.4 ± 6.6 years post-injury
Results

*statistically significant, p-value < 0.05
Handles and resistance dial

Attachment of screen on to base
Alpha Prototype
Focus Group for Alpha Prototype

• Goal: To obtain user feedback on prototype

• Alpha Prototype
  – 18 participants – 8 rehab clinicians, 8 used wheelchairs, 2 combined
  – Average age: 40 years ± 12.4
  – 20 GAME^Cycle Feature Questions and free response
Beta Prototype
• Training Phase
  – Use training sessions on the newly designed GAME\textsuperscript{Cycle} Exercise System (beta prototype) to verify the functionality and ease of use of the new system in local rehabilitation facilities.

• In-Home Phase
  – Use in-home trials to evaluate the effectiveness of the GAME\textsuperscript{Cycle} Exercise System (as compared with an “off-the-shelf” standard arm-ergometer) in the context of extended, in-home use.
Training Phase

• Goals:
  – Training time for new users to learn effective and safe GAME\textsuperscript{Cycle} use
  – Participants ability to reach and maintain aerobic heart zones (60%-80% of max) during 15 minute exercise bout
  – Data collection
    • Stability of system, ease of use, fit, comfort
    • Overall attitude toward product

• Participants with SCI
Methods

• Training phase for Beta Prototype
  – 14 participants
    • 11 men, 3 women
    • all participants use wheelchairs, SCI
  – Average age: 35.7 years (std = 6.5)
  – Same 20 GAME\textsuperscript{Cycle} Feature Questions and free response
Results

• Seven of nine questions significantly higher
  – Stability
  – Ease of assembly/disassembly
  – Ease of position for exercise
  – Steering comfort
  – Amount of vibration
  – Ease of adjustment
  – Overall enjoyment of the GAME\textsuperscript{Cycle}

• Ease of learning and motivation not significantly increased
Discussion

• All subjects were able to complete training successfully and 12 (86%) of the subjects were able to reach their target heart rate zones.

• All of the participants conveyed that the GameCycle™ was easy to learn, operate, and has easily adjustable settings to suit their needs.

• 86% of participants found the GameCycle™ to be enjoyable and that it was likely motivate manual wheelchair users to exercise regularly.
In-home phase

• To evaluate the effectiveness of the Game\textsuperscript{Cycle} as compared to standard ergometry
  – participants will have significantly (p < 0.05) greater physiologic and metabolic activity (VO\textsubscript{2}, HR)
  – participants will adhere to a significantly (p < 0.05) more demanding exercise regimen (exercising longer and more frequently) when using the GameCycle
Methods

• Cross over study
• The first group (n1=5) used the GameCycleTM for two consecutive months of exercise followed by two months of standard arm-ergometry (the GameCycleTM with the video game disabled).
• The second group (n2=6) used standard arm-ergometry for two months before finishing with two months of the GameCycle™
Exercise efficacy

• Most of the respondents (56%) were highly confident that they could continue exercising for 40+ minutes, 3 times a week, for the next week, while 22% were not at all confident and 22% were moderately confident.

• 44% of respondents felt highly confident that they could keep exercising in 8 weeks, with 33% moderately confident and 22% not at all confident.
Physical activity

• Physical activity levels ranged from sedentary to extremely active.

• Some participants met the recommendation (20 – 60mins) using the GameCycle™ alone and some met the recommendation by continuing to participate in other fitness activities.
COMPARISON OF ARM ERGOMETRY WITH AND WITHOUT VIDEO GAMING DURING EXTENDED IN-HOME USE

Theresa Crytzer, Brad E. Dicianno, Rory Cooper
Aim

- To describe participation of a cohort of adults with Spina Bifida in a 3 time per week exercise program using either a GameCycle, or a Saratoga Silver 1 standard arm ergometer under conditions of receiving or not receiving text message reminders to exercise.
Design:
In a quasi-experimental 7 randomized crossover design, the GameCycle was compared to a Saratoga Silver I arm ergometer. Personalized free or low cost text/voice message reminders to exercise were sent.
Methods:
19 young adults with Spina Bifida were assigned to either the GameCycle or Saratoga exercise group.

Within each group, participants were randomized to receive reminders to exercise, or no reminders, then crossed over to the opposite message group after 8 weeks.

Before and after a 16 week exercise program we collected anthropometric, metabolic, exercise testing and questionnaire data, and recorded participation.
Results

• Miles traveled by the GameCycle group were significantly higher than the Saratoga exercise groups

• Number of Participants:
  \[ n = 7 \text{ (GAME}^{\text{CYCLE}}) \]
  \[ n=12 \text{ (SARATOGA)} \]

• Miles traveled:
  \[ \text{GC: } 15.9 (20.1) \]
  \[ \text{S: } 0.9 (0.9) \quad 0.001^{**} \]
Virtual Electric Power
Wheelchair driving simulator

Brad Dicianno, Rory Cooper, Harshal Mahajan, Deepan Kamaraj, Rosemarie Cooper, Annemarie Kelleher, Stacy Eckstein
Kinect and Stroke Rehabilitation

Bambi Brewer, Elizabeth Brokaw
Evaluation of the Home Arm Movement Stroke Training Environment for Rehabilitation (HAMSTER) by Clinicians.

• Stroke is the leading cause of adult disability in the United States\textsuperscript{9}
• Physical Therapy and use of the affected arm is effective for improving function after stroke, but transportation and cost are significant barriers to physical activity\textsuperscript{10}
• Therapists report low compliance with home exercises.
Advantages

- The Kinect can be used in the home and it is low cost
- It can be used to record therapy hours
- Correctness of activities practiced at home
- Record Kinetic variables for clinical follow-ups
Goal to encourage coordinated movement while limiting compensation or “cheating” strategies
Focus Group

- Tested the system with 8 clinicians (40 + 15 yrs old and had 14.4 + 11.7 yrs of clinical experience)
- Only 2 clinicians had used the Kinect before and each had only used it once
- 100% said the system would be helpful for home exercise of individuals with stroke.
Clinician Usability Responses with Standard Deviation

- Bowling: 2.88
- PickNPlace: 3.25
- Ping Pong: 2.75
- Bball: 2.88
- Assessment: 3.38
WII & Occupational Therapy

Callie Hammond, Deepan Kamaraj, Brad Dicianno
WII and OT

Advantages:
1. Motivation
2. Extensive application
3. Easy availability and low price

Dis - advantages:
1. Inconsistent studies
2. Inaccurate tracking by performing minimal movement
## Strengthening Specific Shoulder Motions

<table>
<thead>
<tr>
<th>Motion</th>
<th>Disc</th>
<th>Games</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion/Extension</td>
<td>Wii Resort</td>
<td>Basketball</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bowling</td>
</tr>
<tr>
<td>Internal / External rotation</td>
<td>Wii Resort</td>
<td>Frisbee - Dog</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Table Tennis</td>
</tr>
<tr>
<td></td>
<td>Wii Sports</td>
<td>Tennis</td>
</tr>
<tr>
<td>Protraction / retraction</td>
<td>Wii Sports</td>
<td>Boxing</td>
</tr>
<tr>
<td></td>
<td>Super Monkey Ball</td>
<td>Monkey Boxing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fish catcher</td>
</tr>
<tr>
<td></td>
<td>Let's Tap</td>
<td>All gmaes</td>
</tr>
<tr>
<td>Horizontal Abduction /Adduction</td>
<td>Wii Resort</td>
<td>Frisbee - Golf</td>
</tr>
<tr>
<td></td>
<td>Let's Tap</td>
<td>All games</td>
</tr>
</tbody>
</table>
Projects in development

CAREN

• Power wheelchair Driving skills analysis
  – Different driving elevations and terrains
  – Neuropsychological parameters

• Racing wheelchair biomechanics
• Transition of care from in-patient to out patient care
  – Combining data loggers with virtual reality

• Virtual Reality for Disability Advocacy
Thank You
References

8. Cryzter T, Dicianno B, Cooper R. Comparison of arm ergometry with and without video gaming during extended in-home use. Assistive technology (In review)