Wii-Hab:
Using commercial videogames in rehabilitation after a pediatric trauma

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Virtual Reality in Rehabilitation
Virtual reality in rehabilitation

• Area of practice that is growing and gaining popularity

• Defined as computer based, interactive, multisensory simulation environment that occurs in real time

• Opportunity to engage in multidimensional, multisensory activities that are related to daily life

• Some examples include: motor learning, ADL learning, upper extremity function, mobility, balance, cognition and pain
Virtual reality in rehabilitation

Equipment required

• **Computer** allowing for rapid computation of 3D movements

• **Display devices**
  simple desktop computer with 2D graphic display
  
  ↓

room-sized high resolution immersive environment
Virtual reality in rehabilitation

Equipment

• **Hardware** to monitor kinematics or provide haptic simulations
  
  Any motion tracking device
  
  mouse, joystick
  
  electromagnetic tracking
  
  glove
  
  haptic feedback through vibration...

• **Software** to enable all components to work together
  
  Designed for specific uses, requires lots of programming and development

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Virtual reality in rehabilitation

Rationale for using/theoretical background
• VR as an adjunct for motor learning:
  • **Repetition**: linked to success

  • **Feedback**: can be augmented in VR, creation of new cell activity

  • **Motivation**: in order to tolerate high number of repetition necessary to achieve learning

• VR as a distraction, relaxation and relaxation modality
Virtual reality in rehabilitation

Early findings

• Research consists mainly of small studies without large control groups, more about feasibility and pilot testing

• Some recurrent findings emerging
  1. Patients with disabilities appear capable of learning within VR environments
  2. Movements learned in VR environments appear to transfer to real world
  3. Learning appears increased in VR environments
  4. No occurrences of cybersickness in the available studies

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A few examples of VR with kids
Engaging children with disability

Investigating volition during variety of VR situations and games
Indicates that VR is motivating and has potential as successful intervention tool
Distracting children

• Oncology and chronic pain: some of more conclusive evidence (Review in Parsons et al., 2009)

• Found to be efficient and beneficial analgesic component to pain distraction during variety of painful procedures

• Paired with standard pharmacological analgesics, extremely effective at reducing perception of pain

• Level of immersion needs to be high
Orthopedic trauma

Ankle instability (Girone et al., 2001)

- Rutgers System: Individuals pilot virtual airplane or speedboat and against a resistance

- Improvements found in ankle ROM, torque production, single leg stance duration, task performance
Children with CP

Virtual reality as a therapeutic modality for children with cerebral palsy

LAURIE SNIDER, ANNETTE MAJNEMER, & VASILIKI DARSAKLIS

McGill University, School of Physical & Occupational Therapy, Montreal, Canada
Developmental Neurorehabilitation, April 2010; 13(2): 120–128

Currently, there is a paucity of well designed studies investigating the benefits of VR therapy in the rehabilitation of children with CP. Overall, the level of evidence is poor, as most of the studies are experimental and observational studies with small sample sizes. The results of this systematic review reveal that there is conflicting evidence (Level 4) that VR therapy has positive effects on body structures and functions, a moderate level of evidence (Level 1b) that VR does not positively impact on activity and participation and a moderate level of evidence (Level 1b) that VR therapy positively impacts on personal factors such as motivation, volition and interest.
Trauma Programs and VR

• Presently used in a longitudinal study investigating the consequences of a mild traumatic brain injury on visual perception and postural control

• Psychophysics
• VEP
• Postural control

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Trauma Programs and VR

• Presently used in a longitudinal study investigating the consequences of a mild traumatic brain injury on visual perception and postural control

• CAVE system, Tunnel paradigm

  Used as a means to test postural control in complex environment that is ecologically sound and also fun for kids
VR and clinical practice

• Most of these VR systems can be costly and are not clinically available outside research centers

• For these reasons, VR using flatscreens was explored, to simplify processes

  Preliminary reports promising and similar to more sophisticated systems
  (Sveistrup et al., 2004)

  Functional balance, mobility, enjoyment, independence and confidence

Figure 1. Center of pressure plots for the first (top) and twelfth (bottom) minute of a 25-minute session with a snowboard application (adapted from [1]).
Then came the Nintendo Wii...

And other alternatives
The Nintendo Wii

• Commercially available in 2006 by Nintendo

• Infra-red system
  • Detection bar responds to 3 axis movement and acceleration

• wireless remotes
  • Wiimote
  • Nunchuck
  • Wii Balance Board
The Nintendo Wii

- Feedback to player is multi-sensory (visual, auditory, tactile)
- Nintendo was targeting a new market, making it more active therefore more attractive to non gamers (parents!)
The Nintendo Wii

Benefited Nintendo...

Nintendo Shares Rise After Record Wii Sales in U.S. (Update3)

Jan. 6 (Bloomberg) -- Nintendo Co. rose the most in more than a year in Osaka trading after sales of its flagship Wii game console in the U.S. climbed by more than 40 percent to a record in December.

The stock climbed 6.9 percent to close at 24,500 yen, its biggest gain since November 2008. U.S. consumers probably bought more than 3 million Wii players last month, said Yasuhito Minagawa, a spokesman at the Kyoto-based company. Nintendo sold 2.15 million Wii players in the country during December 2008, according to estimates by research firm NPD Group.

Nintendo ended nine months of sales declines for the Wii after hit games such as "New Super Mario Bros. Wii" and a 25 percent price cut of the motion-sensing console helped spur demand. Sales of its DS handheld player may have also risen to a record last year, the company told on its Web site.

"Nintendo's got a good lineup and we're finally seeing the benefits of the price cuts," said Eiji Mikeda, senior analyst at JPMorgan Chase & Co. in Tokyo. "The new release in the 'Super Mario Brothers' franchise had a huge impact."

U.S. sales of the DS last year probably exceeded the 9.96 million unit record in 2008, Minagawa said, without giving a specific figure. The "New Super Mario" game sold close to 4 million units in the U.S. since its release on Nov. 15, the company said.

Wii sales dropped 35 percent to 1.25 million consoles in November, leading the U.S. video-game market to its eighth drop in nine months, according to NPD estimates. Sales of Microsoft Corp.'s Xbox 360 declined 2 percent to $19.5 billion, while Sony Corp.'s PlayStation 3 sales rose 88 percent to $10.4 billion after a 25 percent price cut in August, the researcher said.

But was also picked up by others...
Wii as a therapeutic tool

- Used clinically quickly
  - Rehabilitation
  - Education

- Little research on actual impact of using it for various conditions
Wii as a therapeutic tool

- Clinical trials: quick search on www.clinicaltrials.gov

Some trials reg

Effectiveness of Virtual Reality Exercises in STroke Rehabilitation (EVREST): Rationale, Design, and Protocol of a Pilot Randomized Clinical Trial Assessing the Wii Gaming System

G. Saposnik\textsuperscript{1*}, M. Mamdani\textsuperscript{1}, M. Bayley\textsuperscript{2}, K.E. Thorpe\textsuperscript{2}, J. Hall\textsuperscript{2}, L.G. Cohen\textsuperscript{3}, and R. Teasell\textsuperscript{4} on behalf of the Steering Committee and EVREST Study Group* 

\textsuperscript{1}Ludwig Pennington Biomedical Research Center, Washington, D.C. 

\textsuperscript{2}Novel Health, Toronto, ON, Canada 

\textsuperscript{3}VA Medical Center, Minnetonka, Minnesota 

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Comparison of Efficacy Between Traditional and Video Game Based Balance Programs

Kirk A. Brumels, PhD, ATC, Troy Blasier, Tyler Cottright, Daniel Oumedian, and Brent Solberg

Hope College, Holland, MI

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Wii as a therapeutic tool

• A few observational studies
• A few case reports

Doing WiiHab: Experience With the Wii Video Game System in Acquired Use of a Low-Cost, Commercially Available Gaming Console (Wii) for Rehabilitation of an Adolescent With Cerebral Palsy

Judith E Deutsch, Megan Borbely, Jenny Filler, Karen Huhn, Phyllis Guerrera-Bowldy

B. Manijeh

If

Video “Games” in the Clinic: PTs Report Early Results

By Claire Coyne

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What do we know?
Wii as a therapeutic tool: physical activity

- Promoting physical activity: energy expenditure

### Energy expenditure in adolescents playing new generation computer games

Results indicate that new generation computer games generate more energy expenditure than sedentary ones.

However, games in Wii sports not high enough intensity for daily amount of exercise in older children.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Predicted energy expenditure</th>
<th>Actual energy expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resting energy expenditure</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>XBOX 360</td>
<td>2.7</td>
<td>430</td>
</tr>
<tr>
<td>Wii bowling</td>
<td>11.7</td>
<td>700</td>
</tr>
<tr>
<td>Wii Sports tennis</td>
<td>12.5</td>
<td>750</td>
</tr>
<tr>
<td>Wii Sports boxing</td>
<td>12.1</td>
<td>730</td>
</tr>
<tr>
<td>Various activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sitting playing board games</td>
<td>6.7</td>
<td>400</td>
</tr>
<tr>
<td>Bowling</td>
<td>13.3</td>
<td>800</td>
</tr>
<tr>
<td>Tennis (doubles)</td>
<td>22.2</td>
<td>1330</td>
</tr>
<tr>
<td>Boxing (punch bag)</td>
<td>26.8</td>
<td>1600</td>
</tr>
<tr>
<td>Boxing (sparring)</td>
<td>40.1</td>
<td>2410</td>
</tr>
</tbody>
</table>

We calculated values for the various activities using metabolic equivalents.
Wii as a therapeutic tool

Increasing energy expenditure: tips

- Older children and adults tend to expend less energy than younger children who move more during activity

  Increase of 189 kcal/hour for children vs 148 kcal/hour for adults for same game

  Need to engage whole body!
Wii as a therapeutic tool: Balance

Balance training traditional vs videogames (Brumels, 2008)

Comparison of Efficacy Between Traditional and Video Game Based Balance Programs
Kirk A. Brumels, PhD, ATC, Troy Blasius, Tyler Cortright, Daniel Oumedian, and Brent Solberg
Hope College, Holland, MI

Found that use of video game based programs increase patient enjoyment and engagement, decrease perception of difficulty, but they also improve selected balance performance measurements
Wii as a therapeutic tool: Balance

- Adolescent with CP (Deutsch, 2008)

**Table 3.** Preintervention and Postintervention Measurements on the Posture Scale Analyzer (PSA)

<table>
<thead>
<tr>
<th>PSA Measures</th>
<th>Preintervention</th>
<th>Postintervention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Eyes Open</td>
<td>Eyes Closed</td>
</tr>
<tr>
<td>Percentage of body weight</td>
<td>96</td>
<td>89</td>
</tr>
</tbody>
</table>

Improvements in postural control, visual-perceptual processing, and functional mobility were measured after training
Wii as a therapeutic tool: TBI

Doing WiiHab: Experience With the Wii Video Game System in Acquired Brain Injury Rehabilitation: 0034

Goldberg, Gary; Rubinsky, Hillel; Irvin, Erin; Linneman, Emily; Knapke, Jennifer; Ryan, Manijeh

• Tested 8 adults with ABI in in-patient rehabilitation
• 1 hour/week, group session

No clinical measures presented
Reports of improved eye-hand coordination,
Increased social participation
Decreased helplessness
Not much out there but...
There will be more
What is Wii-hab?

Wii-habilitation was introduced to the nation in early 2008 as an adjunct to physical and occupational therapy programs, using Nintendo’s new motion-sensitive gaming platform, the Wii™. This revolutionary tool quickly became favorable within the rehab industry and a nationwide media storm covered the implementation of Wii-hab programs across the country. Since that time, a few key modifications have been made to improve the motion-sensitive gaming hardware including Wii Fit™ with the pressure sensitive balance board and Wii Motion Plus™, an attachable device to enhance the sensitivity of our body’s motions.

Wii-hab is the medical application of interactive video gaming devices to augment therapies of physical, cognitive, behavioral, and otherwise, under the guidance of a trained and licensed healthcare professional.
Using the Wii in pediatric trauma rehabilitation
MCH Trauma Programs

• Neurotrauma Program
• Trauma Program
• Burn Trauma Program
• Concussion & Return to Sports Program
• Injury Prevention Program

Where would VR be useful?
Trauma Wii initiatives

Exploring the Wii as an alternative for aerobic activities in the mild traumatic brain injury/return to sports clinic
MTBI Clinic Stream 1: Exertion Test

Referral to Concussion/Return to Sports clinic
(team members include: trauma coordinator, clinic coordinator, physiotherapist, psychologist, neurosurgeon, other consultants as needed)

WHO: Active children involved in > 8 hours/wk sport participation

WHY: Some deny symptoms, prevent early return to activities

WHEN: After one week symptom free

WHAT: Standardized evaluations, physical and cognitive exertion tests

Elite athletes symptom free at rest for 1 week

Initial evaluation: History, physical, and appropriate cognitive evaluation

Physical and cognitive exertion testing

Remains symptom free

Yes

Gradual return to sports guidelines

Gradual return to sports

Discharge from clinic

No

Asymptomatic for 1 week

-Return appointment for re-evaluation

-Education and weekly follow-up
MTBI Clinic Stream 2: Active Rehab

Referral to Concussion/Return to Sports clinic
(team members include: trauma coordinator, clinic coordinator, physiotherapist, psychologist, neurosurgeon, other consultants as needed)

Elite athletes symptom free at rest for 1 week

Initial evaluation:
History, physical, and appropriate cognitive evaluation

Physical and cognitive exertion testing

Remains symptom free

Yes

Gradual return to sports guidelines

Gradual return to sports

Discharge from clinic

No

Children with slow recovery

Initial evaluation:
History, physical, and appropriate cognitive evaluation

-Graded rehab (MCH-RAC) until asymptomatic for 1 week
-Management by team: PT, psychologist, MD, etc.

Asymptomatic for 1 week

-Return appointment for re-evaluation
-Education and weekly follow-up
MTBI Clinic Stream 2: Active Rehabilitation

• Eligible if symptomatic or have impairments after 4 weeks
• May have more severe injury than anticipated
• Pre-morbid characteristics placing them at higher risk of functional complications (medical conditions (ex. migraines); previous TBI; familial stressors; personality; behavioral problems or learning problems; psychiatric disorders (depression, anxiety)

Decrease persisting symptoms, **early rehabilitation** initiated (physical and cognitive)
• Clinical program with interesting anecdotal evidence based on following principles
  Exercise has a cerebral effect
  May contribute to neural repair and vascular auto-regulation
  Contributes to improve mood and energy level

Gagnon, Galli, Friedman, Grilli, Iverson., Brain Injury, 2009
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Wii as alternative for aerobic activities

Development of a protocol for aerobic activities: 2 phase process

1. Structured literature review re:
   • use of VR for aerobic activities
   • Use of Wii and other commercial videogames in rehabilitation (if possible with children)

2. Experimentation process
   Testing of various games to determine suitability
   • Using polar heart rate monitor and chest strap
   • Ability to practice game and sustain HR > 50-60% of max capacity (for use in the clinic)

Emond, Lechasseur, Gagnon, 2010 (submitted)
Wii as alternative for aerobic activities

- Wii sports (boxing) considered not suitable, unless for younger children who practice it with whole body

- Wii FIT considered unlikely to generate enough METS

- Wii FIT plus better choice
Wii FIT plus

• Recommended exercises (60 to 70% max HR)
  – Running
    • Aerobics - Basic Run, 2-P-Run, Free Run
    • Training Plus - Basic Run Plus
  – Step
    • Aerobics - Basic Step, Advanced Step, Free Step
  – Complementary exercise (50 to 60% max HR)
    • Hula Hoop

Potential problems

• Running on the spot
• Movement unnatural
• Excessive plantarflexion
  • ↑fatigue

Recommendations

• Use the Wii active thigh band with Wiimote
• Use of stationary bicycle and treadmill possible
• Need running shoes
• Encourage arm movements

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Gold’s Gym cardio workout

• Recommended exercises (60 to 70% max HR)
  – Cardio Kick Boxing
    • Shape Boxing
  – Jump rope
    • Exercise – Jump Rope

• Complementary exercises (50 to 60% max HR)
  – Running
  – Punching Bag
Wii Active

• Recommended exercises (60 to 70% max HR)
  – Running
    • Cardio - Run and Walk, Run, Walk and Run, Kick ups, Run, knees and kick ups, Track random
  – Jump
    • Lower limbs exercises - Jump Squats, Side to side jumps
    • Sports – Shooting, Inline Skating
• Complementary exercises (50 to 60% max HR)
  – Box
  – Cardio dance
Wii Active more workouts

- Recommended exercises (60 to 70% max HR)
  - Course
    - Cardio – Sprint, Follow the leader, Island outrun
    - Fitness activities – Obstacle course
  - Jumps
    - Cardio – Stride jumps, Skipping
    - Lower body exercises – Forward-backward ankle hops
    - Fitness activities – Water skiing
  - Step
    - Fitness activities – Step aerobic
Wii Active more workouts

• Recommended exercises (60 to 70% max HR)
  – Others
    • Fitness activities – Paddle surfing
  – Pre-Set Workouts
    • Cardioresp training program

• Complementary exercises (50 to 60% max HR)
  – Box
What’s next?

• Pilot testing with children in the clinic to begin in the summer of 2010

• Measures of satisfaction, enjoyment, as well as monitoring of effort perception and HR

• Compare with children who are seen now consecutively in the clinic
Trauma Wii initiatives: balance

Exploring the impact of a physiotherapy intervention on the risk of re-injury and recovery in children and adolescents with acute ankle sprains: a randomized controlled trial
Ankle sprain rehabilitation

Objectives
1) determine the impact of providing individualized PT intervention in addition to standard care on risk of re-injury in the first year following an initial ankle sprain in children and adolescents presenting to a pediatric ED,

2) document recovery and return to activities following ankle sprains in children receiving both types of intervention 12 weeks post-injury
RCT planned to start late 2010

Children presenting in the MCH ED with a confirmed diagnosis of ankle sprain

ED RA meets and explains study/obtains consent Administers questionnaires and performs assessments (T0)

Randomization

Intervention group
- ED management
- MCH ankle KITD
- Individualized physiotherapy

Pre-intervention assessment within 2 weeks post-injury (T1) (45 minutes)

Intervention
- Biweekly follow-up x 3 mos

Post-intervention assessment 12 weeks post-injury (T2) (45 minutes)

Surveillance for one year (phone assessment every month)

Data analysis (intention to treat)

Control group
- ED management
- MCH ankle KITD

Standard of Care
Balance training

• Physiotherapy intervention to include
  • mobilization,
  • strengthening,
  • balance and proprioception training and,
  • if the child is involved in sports, activity specific exercises, such as those described in

Potential for use of VR
Ankle sprain intervention

• Strengthening example

Sitting strengthening exercise
Ankle sprain intervention

- Balance and proprioception training examples
  - On 2 feet
  - On 1 foot
Ankle sprain intervention

• Awaiting funding for clinical trial (collaboration with University of Calgary, Drs C. Emery and D. Johnson)
• Developing the physiotherapy intervention and deciding on Wii content
• Advantage: once exercises are taught, could be used as a home program
Other potential uses in trauma

- Motivation and cognitive training for severe TBI
- Distraction for painful procedures
- Strengthening and balance training after fractures
- Remains to be explored...
Some limitations

• Not specific to rehabilitation
• Not adapted to all clienteles
  • Range of motion/need grasping abilities/reaction speed
• Progression may be too rapid
• Games may be too difficult (e.g. dance dance revolution)
• Undesirable movement patterns
Muscular pain
  – Following a sudden and intense increase in physical activity level

Wii-shoulder

Wii-knee – Patellar dislocation

Pneumothorax

Internal carotid dissection with associated CVA

Reports of injuries

Recommendations

- Evaluate physical condition of patient
- Reasonable level of training
- Adequate monitoring
- Supervision
- Safe environment
Conclusion

• Different therapies & modalities come and go
• Theoretical background remains the same
• Choosing any therapeutic tool relies on sound reasoning that supports the client’s desired outcome
• It requires the expertise of a skilled therapist to monitor, modify and evaluate
Conclusion

- Wii is interesting, potential low cost alternative to standard VR systems
- Potential uses remain to be developed
- Research is scarce and remains to be undertaken

- Remember why you want to use it
- Follow logic intervention
- Supervise children
Questions