Overview of CAREN Research

State of the Science Symposium: Virtual Reality and Its Role in Wounded Warrior and Veteran Care

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What is CAREN

- Computer Assisted Rehabilitation Environment

Virtual Environment

- Rehabilitation Modality
- Research

Hardware

Software
What is CAREN

• Hardware
  – Motion Base – Stewart Platform
    • 6 Degrees of Freedom
    • X, Y, and Z translation
    • Roll, Pitch, and Yaw Rotation
  – Motion Capture System
  – Instrumented Treadmill
  – Projection System
  – Safety Harness

What is CAREN

• Software
  – D-Flow software links and controls components
Participant Interaction

• Safety
  – Realistic Environments in a “Clinical Setting”

• Flexibility
• **GRAIL (Gait Real-Time Analysis Interactive Laboratory)**
  – Evaluates treadmill gait and outputs real-time kinematics and kinetics

• **STABLE (Stability and Balance Learning Environment)**
  – Assessment and training of balance disorders in a virtual environment

• **Human Body Model**
  – Uses inverse dynamics to estimate muscle forces and visualize them in a virtual environment in real-time
Research Populations

• Uninjured
• Lower Extremity Trauma
• Stroke
• Spinal Cord Injury
• Orthopedic Injury
• Traumatic Brain Injury
• Post Traumatic Stress Disorder
• Vestibular Injury
• Visual Impairment
• 1999 – Paper published describing the Computer Assisted Rehabilitation Environment
• Describes how the platform is controlled and how the patient interacts with the device

Barton et al (2006) evaluated device control with respect to other similar platforms.
- Manipulated the axes of rotation of the device
- Flexible system with regard to creating rotations around various axes
Lees et al (2007) continued to explore the kinematic characteristics of the device
- Created technical specifications for use with research or clinical protocols
- Showed that the device was exceptionally well suited for multiple degree-of-freedom perturbations

Makssoud et al (2009) explored the patient interaction with the virtual environment an Created and implemented dynamic rotation corrections. Single subject testing showed improved trunk dynamics and less variable speed.

• Hawkins et al (2008) examined the effects of game speed and surface perturbation
  – Increased game speed and perturbation led to decreased performance
  – Concluded that adaptability of the CAREN would make it a good rehabilitation tool
Bartlett and Sessoms (2012) showed that optic flow contributed to walking speeds closer to that of overground.
Uninjured Testing

- Collins et al (2012) showed that patient controlled treadmill speed was no different than feedback controlled speed.

Hak et al (2012) disturbed participants with quasi-random perturbations in the medio-lateral direction:
- No change in speed
- Decreased step length
- Increased step frequency and step width
Uninjured Testing

• McAndrew et al (2010) applied continuous oscillations of either the walking surface or the visual field in the medio-lateral (ML) and antero-posterior (AP) directions
  – Decreased step length and increased step width for both directions
  – Decreased step length and increased step width for both ML versus AP

• McAndrew et al (2011) used the same methodology to evaluate stability using Floquet Multipliers
  – AP direction displayed greater instability from platform motion
  – ML direction displayed greater instability from visual field motion

Subramanian and Levin (2011) compared a reaching task in patients with stroke:
- Head mounted display (HMD) versus CAREN
- No difference in trajectory straightness or shoulder kinematics

• Kizony et al (2010) looked at self paced walking while performing a shopping task
  – Stroke group increased walking speed, uninjured decreased
  – Coping strategies were variable but participants were able to complete tasks with minimal mistakes

• Gottshall et al (2012) utilized CAREN in lieu of standard therapy for patients with mild TBI
  – Patients showed improvements in balance, gait, and visual measures after 6 weeks of training
• Rabago and Wilken (2011) conducted a case study of a patient with mild TBI
  – Immersion therapy within the CAREN showed improvement in gait and balance
• Vrieling et al (2008) examined standing balance on subjects with unilateral transtibial amputation
  – Adjustments in response to AP oscillations occurred in the intact limb
Darter and Wilken (2011) conducted a case study on a patient with unilateral transfemoral amputation
- 12 CAREN sessions with real-time visual feedback
- Decreased pelvic and trunk motion
- Decreased oxygen consumption by 23%

Kruger et al (2009) looked at a single patient with bilateral amputation:
- Participated in CAREN for 6 months
- Performance improved even with increased difficulty
- Walking speed and cadence increased
- Step width decreased
Kruger (2010) examined patients with varying injury levels:
- Ranged from unilateral transtibial to bilateral transfemoral
- 7/11 performed 3 consecutive attempts of a walking application in their first session
- All patients improved in walking speed over 3 attempts
Everding and Kruger (2011) explored improvement over time for patients with varying injury levels. All 3 patients improved their times on a dynamic balance application over time.

V Everding and S Kruger. Virtual reality enhanced balance training for Service Members with amputations. International Conference on Virtual Rehabilitation, Zurich, Switzerland, 2011
• Werner et al (2012) applied lateral perturbations to subjects with unilateral transfemoral (TFA) amputation during gait
  – Control participants made minor adjustments to recover
  – TFA made very little adjustment with the prosthetic limb and relied on their intact limb to recover

Lower Extremity Injury

• Wyatt et al (2012) implemented a training intervention to reduce falls
  – Used CAREN to evaluate biomechanical response to trip
  – Decreased trunk flexion angles and velocities indicating improved ability to recover from a trip

Limitations of CAREN Research

• Consistency between systems

• Translation and implementation of research findings to the clinical setting
  – Wii
  – Kinect
  – Neurocom
  – vGait

• Has CAREN been validated as a research tool?
Future Research

• More realistic environments
  – 3 dimensional worlds

• 2 dimensional treadmill
  – Would allow for complete freedom of movement in a virtual environment

• Integration of other technology
  – Brain interface
  – Olfactory sensation

• ????
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