Feasibility of Interactive Biking Exercise System for Telemanagement in Elderly

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\textsuperscript{2} Baltimore VA Medical Center
Introduction: Exercise for Healthy Aging

• Exercise is considered to be an essential component of healthy aging

Verney J et. al 2006
Introduction: Exercise for Disease Management

- Comprehensive disease management programs include exercise to promote quality of life and rehabilitation in elderly with chronic health conditions.
Introduction: Cycling Exercise

- Cycling exercise training has been shown to improve clinical outcomes in patients with chronic health conditions and promote rehabilitation in older adults
  - Improved clinical outcomes were reported to improve after cycling exercise in
    - patients with chronic obstructive pulmonary disease
    - patients in post-acute recovery phase after stroke
    - patients recently weaned from mechanical ventilation

Matta T et al. 2011
Costi S et al. 2009
Harris JE et al. 2010
Porta R et al. 2005
Introduction: Cycling Equipment

- Cycling equipment is widely used in rehabilitation facilities where patient exercise may be supervised.
- Low-cost cycling equipment is also available for use at home.
Introduction: Barriers to Exercise

• However, effective use of these simple low-cost exercise devices at patient homes is hampered by:
  – inability to monitor exercise progress in real time using simple graphical and numerical representation
  – absence of an alert system which would prevent exertion levels exceeding those approved by patient care providers
  – lack of remote connectivity allowing data exchange with a clinical care management team
Introduction: Current Limitations

• Despite this growing demand for safe and effective home-based exercise systems designed for elderly, limited research has been conducted in utilizing telemedicine to promote use of cycling equipment for geriatric rehabilitation.

• Previously, we demonstrated high acceptance and positive clinical impact of a physical telerehabilitation system in older adults.

Finkelstein J et al. 2012
Goals

• Describe design and implementation of a low-cost practical system facilitating safe cycling exercise at senior citizen homes and to assess its feasibility

• Extend our successful experience in implementing chronic disease telemanagement systems by supporting safe and effective home-based biking exercise in older adults
Home Automated Telemanagement (HAT) system

Self-care
Clinical Decision Support
Care Coordination

Patient-Provider Communication
Disease Education
Individualized Treatment Plans
Health Life Style Counseling
Social Support

Patient-Centered Care Delivery Model
iBikE HAT Information Flow

Clinical Care Team

HAT Central Server
- Patient Profile
- Medications
- Diet
- Exercise
- Mental Health
- Social Support
- Health Education
- Alternative Medicine

iBikE Communication Server

iBikE OUT.xlsx

iBikE IN.xlsx

Multi-Component Individualized Treatment Plan
- Symptom diary
- Medication Reminders
- Healthy Diet
- Exercise Plan
- Mood Log
- Support Groups
- Interactive Education
- Stress Reduction & Meditation

Home-based Cycling Exercise
- Exercise log
- Exercise Prescription

iBikE Home Unit
iBikE.txt

Exercise Dashboard
Technical Design of HAT system

Clinician Unit
- Presentation Module
- Communication Module

HAT Server
- HAT Database
- Decision Support Module
- HAT Web Server

Patient Unit
- Data Collection Module
- Presentation Module
- Computing Module
- Communication Module
HAT Web Interface

Patient-Provider Communication
Disease Education
Individualized Treatment Plans
Health Life Style Counseling
Social Support

Self-care
Clinical Decision Support
Care Coordination

medinfo 2013
Healthcare Delivery Model

JOHNS HOPKINS
SCHOOL of MEDICINE

U.S. Department of Veterans Affairs
HAT Applications

- Computer-assisted education in patients with multiple sclerosis [2004]

- Interactive asthma learning system utilizing a mobile phone platform [2008]

- Using cell phones for chronic disease prevention and management [2008]

- Home-Based Physical Telerehabilitation in Patients with Multiple Sclerosis [2008]

- Digital divide: variation in internet and cellular phone use among women attending an urban sexually transmitted infections clinic [2010]

- Feasibility of congestive heart failure telemanagement using a Wii-based telecare platform [2010]

- Implementing Home Telemanagement of Congestive heart Failure Using Xbox Gaming Platform [2011]

- Comprehensive disease telemanagement in veterans with multiple sclerosis [2013]
Technical Design of iBikE HAT System
**iBike Components**

**Exercise monitoring software**
(National Instruments, USA)

**ECG sensor, PPG sensor, Accelerometer**
Shimmer Research, Dublin, Ireland

- 3 axis 12 bits accelerometer signals with the 1.5g range and the 0.024g sensitivity and the sampling rate 51.2 Hz

- Lead II 16 bits ECG signal with the 0.05 to 159 Hz frequency range and the sampling rate 204.8 Hz

**Class 2 Bluetooth radio communications**
iBikE HAT System

Exercise Information viewed on Dashboard

Modification Plan

Prescription Plan

Exercise Status & Alarm

iBikE Home PC

Pairing Information

Exercise appliances

ECG

PPG

SpO2

Blood Pressure

Activity

Calories Consumption

Home

Patient

Heart rate

Activity

Biking apparatus

Bio-signal Sensors

medinfo 2013
COPENHAGEN

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U.S. Department of Veterans Affairs
Home-Based Interactive Cycling

Please confirm the **Target Goals** of your exercise

<table>
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<th>Max Speed</th>
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<table>
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<td>0.07 miles</td>
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**Johns Hopkins University**

Chronic Disease Informatics Program
iBikE HAT Program

HAT Central Server  iBikE Server

iBikE Home Unit

(a) Prescription page
(b) Connection page
(c) Dashboard page
(d) Raw data page
iBikE HAT Program
iBikE HAT Program

- **HEART RATE**: 93
- **SPEED**: 1.7
- **DISTANCE**: 0.12
- **EXERCISE TIME**: 02:58
- **HEART RATE**: 93
- **BLOOD PRESSURE**: 140
- **CALORIES BURN**: 4

**Diagrams**:
- Graphs showing speed, distance, and heart rate trends.
- Visual representation of a bicycle之旅 with indicators of heart rate, speed, and distance.

**Software Screenshots**:
- Screens showing user interface with options for prescription, contacts, and data.
## Accuracy of Cycle Count and Reliability of Alarm detection

### Comparing the monitor’s blind-count and the numeric count indicator

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<th>Subject</th>
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### Analyzing the ability to detect cycling speed reaching a pre-setup threshold

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Next Step: iBikE Exercise Control Unit
Calibration of Remotely Controlled iBikE system

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<th>SE</th>
<th>Mean</th>
<th>SD</th>
<th>SE</th>
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R² = 0.9959
Validation of Remotely Controlled iBikE system

\[ y = 8.492x^{-0.518}, \quad R^2 = 0.9938 \]

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</table>
Summary of Results

- iBikE HAT allows remote setting of individualized patient exercise prescription and its continuous update by a team of clinical experts.
- iBikE HAT ensures safety of unsupervised exercise in elderly with multiple chronic health conditions by implementing a real-time decision support for alert generation based on exercise intensity and physiological monitoring of the patient.
- iBikE HAT supports bi-directional information exchange between home unit and care coordination team including exercise log, symptom diary, and patient and provider messaging.
- iBikE HAT is integrated into a multi-component disease management system aimed at implementing guideline-concordant care and individualized treatment plans supervised by a care coordination team.
- iBikE HAT allows remote exercise control.
Discussion

• Based on our pilot testing in healthy volunteers, iBikE HAT system provided correct representation of all exercise parameters.

• iBikE HAT program can be potentially implemented on other devices supporting physiological signal sensors and accelerometers such as iPads or iPhones.
Limitations and Future Research

• The limitation of the current study is that it was done in a small sample of healthy volunteers.

• In our previous work, we demonstrated that the HAT system was well accepted by patients with chronic health conditions and it improved clinical outcomes in older adults. (Finkelstein J et al. 1998, 2003, and 2007)

• The next step of the project will be assessing the clinical impact of iBikE HAT system in a representative sample of older adults.