**Integrating Concepts of Behavioral Change and Technology to Promote Health in Persons with Arthritis**

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**Objectives**
- Review array of behavioral interventions to promote adherence to treatments and well-being in persons with arthritis
- Describe the application of various technologies to promote behavior change
- Synthesize the evidence for technological applications, highlight strengths and weaknesses
- Describe new areas for applications of technology

**Behavioral Interventions**
- Interventions designed to affect the actions that individuals take with regard to their health.
- With behavioral interventions, in contrast, patient behavior is the key and the goal is to change it.

**Behaviour Change Models and Interventions**

<table>
<thead>
<tr>
<th>Behavioral Interventions</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Behavioral Therapy (CBT)</td>
<td>Based on Cognitive Model of Emotional Response - concept that our thoughts cause our feelings and behaviors, not external things</td>
</tr>
<tr>
<td>Motivational Interviewing</td>
<td>Counseling to facilitate and engage intrinsic motivation within client to change behavior</td>
</tr>
<tr>
<td>Behavior Reinforcement</td>
<td>Stimulus-Response, Reinforcement of desirable behaviors (e Weight Watchers)</td>
</tr>
<tr>
<td>Health Belief Model</td>
<td>Patient beliefs drive change</td>
</tr>
<tr>
<td>Mindfulness</td>
<td>Meditation-based; focus attention/ awareness</td>
</tr>
<tr>
<td>Transtheoretical Model</td>
<td>Conceptualizes intentional behavior change – series of stages with strategies</td>
</tr>
<tr>
<td>Theory of Planned Behavior</td>
<td>Links beliefs, attitudes and behavioral intention</td>
</tr>
<tr>
<td>Social Cognitive Theory</td>
<td>Knowledge acquisition directly related to observing others within social contexts</td>
</tr>
</tbody>
</table>

**Select References**
Targets for Behavioral Interventions

- National Interventions - Public Policy
  - Environment
  - Patient

Patient Health Beliefs
- Barriers
- Facilitators

Targets for Behavioral Interventions

- Environment
  - Safety
  - Social Norms, Social Beliefs
  - Access

National Interventions - Public Policy
- Smoking bans
- "Sin" taxes
- Medication Access/Insurance
- Structural changes in community

External Influences on Technology and Health

Global Advances in Medical Care
- Shifts in Health Care Provider and Patient Demographics
- Economic Factors affecting health care delivery
- Health Care Policy

Increased Disability
- Technology Applications in Health Care
- Increased Technology and Access to Technology

Technology Applications for Health

- mHealth
  - Text messaging
  - Video messaging
  - Voice calling
  - Internet Connectivity
  - Mobile Monitoring
    - Accelerometers
    - Crowd Sourcing
Technology Applications for Health

- Active Assistant Technology
- Telemedicine
- Gaming
- Virtual Reality

Virtual Reality and Health

- VR technology creates controllable, interactive, multisensory environments allowing measurement and motivation of human behavior
- Nonimmersive VR - uses modern computer and console games systems. Format - 3D graphic environment on flat screen monitor, projection system or TV within which the user navigates and interacts.

Virtual Reality and Health

- "Immersion VR - combines computers, head-mounted displays, body tracking sensors, specialized interface devices and real-time graphics to immerse subjects in a computer-generated simulated world that changes in a natural way with head and body motion".

Applications of Virtual Reality

- Medication adherence
- Patient Counseling
- Rehabilitation
- Physical Activity

Design Strategies for Technologically-Based Behavioral Interventions

- Contextual Inquiry
- Value Specification
- Design prototypes
- Operationalism
- Summative Evaluation

Online Prevention Programs to Promote Healthy Behaviors

- Internet-based behavior change – diet, physical activity, alcohol use, smoking, and condom use.
- 41 eligible reviews – mostly weight-related behaviors, eg physical activity and diet
- Effects are small, variable, not sustainable.
- Users - female, well educated, white living in high-income countries.
- Low use of the interventions

Lange et al. Disability & Rehabilitation, 2012

Van Velsen et al, JMIR Res Protoc 2013;2(1):e21

Kohl et al, J Med Internet Res 2013;15(7):e146
Mobile Texting and Alignment with Health Behavior Change

- Texting compatible with
  - Theory of Planned Behavior (Ajzen & Fishbein)
  - Health Belief Model (Becker)
- Provides cues to action, social support and reinforcement of behaviors

Text Messaging for Health Promotion and Disease Prevention

- Systematic Review
  - Text messaging primary Rx
  - RCTs and CCTs - 17 articles (12 studies; 5 prevention 7 disease management)
  - Samples: Most with persons with DM, physical activity and weight loss in general
  - RxS range from 3 to 12 months
  - Message frequency variable
  - 8/9 well powered studies – evidence for success with texting to promote + health behavior

Pro and Cons of Mobile Texting for Health Behavior

- Pros
  - Widely available
  - Inexpensive
  - Instant
  - Does not require tech expertise
  - Applicable to many health conditions
  - Asynchronous = convenient
  - Phone off, messages delivered when on

- Cons
  - Potential to marginalize groups
    - Low literacy
    - Access issues
  - Intervention interrupted if phone lost or stolen

Physical Activity in Adults with Rheumatoid Arthritis

- Design/Sample: Cohort: 1,108 adults with RA followed for 4 years
- RA disease activity contributed little to PA, adjusting for other factors.
- Despite low disease activity, some patients did not engage in PA
- Factors associated with greater PA included female gender, greater social networks, modest alcohol intake and greater education
- Patients with RA engage in low levels of PA even as disease activity subsides.

Technology to Promote and Document Physical Activity (PA)

- Web-based
- Accelerometers
- Computer games (Wii Fit)
  - Non-immersion
  - Immersion
- Customized video-based exercise programs via TV, computer or smart phone (Real Solutions)

Web-based Interventions To Promote Physical Activity

<table>
<thead>
<tr>
<th>Author (Yr)</th>
<th>Design/ Sample</th>
<th>Intervention</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lorig, 2008</td>
<td>RCT of 855 adults with RA, OA or FM</td>
<td>Internet arthritis self-management (IASM)</td>
<td>1 year, IASM significantly improved in 4/6 health status measures and self-efficacy. No significant differences in health behaviors.</td>
</tr>
<tr>
<td>Bossen, 2013</td>
<td>Pre-post design of 20 adults with KGA and KDA (50-85yrs)</td>
<td>Join2move web-based program for 12 wks - uses behavior graded activity theory</td>
<td>Change in pain at 6 wks gone at 12 wks, convenient but issues with interface.</td>
</tr>
<tr>
<td>Krein, 2013</td>
<td>RCT of 229 Vets with chronic LBP</td>
<td>Join2move web-based program for 12 wks - uses behavior graded activity theory</td>
<td>Clinically significant increase (2 pts on Roland Disability) seen at 6 not at 12 months.</td>
</tr>
</tbody>
</table>
Factors Influencing Success With Web-based PA Program Use in OA

- **Facilitators**
  - Trust in the program
  - Reliability, functionality of the intervention
  - Social support from family or friends
  - Research team and commitment

- **Barriers**
  - Age (older)
  - Greater co-morbidities
  - Lack of personal guidance
  - Insufficient motivation
  - Physical problems
  - Low mood
  - Absence of human involvement


Gaming Interventions To Promote Physical Activity

<table>
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<th>Design and Sample</th>
<th>Intervention</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitz, 2010</td>
<td>Pre-Post design: 10 women (30-50 yrs)</td>
<td>WiiFit 30 min, 2x/wk for 10 weeks</td>
<td>Unilateral stance and UE strength significantly increased</td>
</tr>
<tr>
<td>Chang, 2011</td>
<td>ABAB design: 2 young adults – 1 with CP and 1 with acquired muscle atrophy</td>
<td>Kinect-based system with video and audio feedback, 12 days on-5 days off</td>
<td>Increased motivation for exercise and improved exercise performance</td>
</tr>
<tr>
<td>Owen, 2011</td>
<td>Cross-over design: 21 subjects from 8 families</td>
<td>WiiFit used in home for 3 months</td>
<td>Among children sign. increase in VO2; no significant changes in adults; 82% decline in use after 1st 6 weeks to 2nd 6 weeks</td>
</tr>
<tr>
<td>Yuan, 2011</td>
<td>Pre-Post design: 15 AA women with SLE</td>
<td>WiiFit 30 min, 3 days/wk for 10 weeks</td>
<td>10 pt change in Fatigue Severity Scale (0.002) and 2 kg weight loss</td>
</tr>
</tbody>
</table>

Associations Between Gaming System Balance and Clinical Balance Measures

- 34 community dwelling adults (25 F, 9 m)
  - mean age 67 yrs

- **Measures**
  - Balance – Useful Field of View (UFOV), Activiti specific Balance Confidence
  - Functional-Senior Fitness Test, grip dynamometry, 30s chair stand, Timed Up and Go, 6-min walk, etc

- **Results**
  - Low correlation (r=0.3) between Wii Basic Balance and UFOV

Reed-Jones, Gait & Posture, 2012

What is the Metabolic Value (METs) of Commercial Games?

- Assessed Energy Expenditure (EE) of 12 adults during gaming
  - Rx: WiiFit (golf, bowling, tennis, baseball, boxing) and WiiFit Plus (63 activities eg yoga)
  - Methods: EE assessed in open-circuit indirect metabolic chamber
  - Results:
    - Activities ranged from 1.3 to 5.6 METs
    - 67% were light intensity (<3 METs)
    - 23% were moderate intensity (3-6 METs)

Miyachi, Med Sci Sports & Exercise, 2010

Addressing Access - Biosensor-based Video Game for Physically Disabled

- **Target**: Persons with Rheumatoid arthritis

- **Problem**:
  - Pain and synovitis- wrist/fingers
  - Poor lever arms
  - Weak prehension
  - High prevalence Carpal Tunnel

Designers:
  J Breugelmans, Y Lin, RR Mourant, MD Iversen
  Northeastern University

- Combines eye tracking device and data glove technology
  - Personalized – client’s ROM required and inputted into system as game controls.
    - Any small but intentional finger flexion triggers flexion sensor - same with thumb sensor
    - Wrist sensor placement requires 20 degree ROM
  - Game provides reinforcements to encourage play

[http://www.youtube.com/watch?v=sr6ispd7UxeE](http://www.youtube.com/watch?v=sr6ispd7UxeE)
RPLAY – Aims & Challenges

- Social Cognitive Theory basis of Rx
  - Monitors clinical outcomes & merging data for feedback loop
  - Adaptation of KINECT system
  - Games calibrated to patient-specific needs
  - System gains intelligence with use
  - E-community built into gaming

Emotion Detection and Motion Feedback - RPLAY

- Use web camera
- The bottom preview window shows the real-time images.
- Every 1.5 seconds, the face is detected, shown in “Detected face” windows
- Classified into one emotion category shown by the cartoon

25 studies 1980-2011 (PubMed, CINHAL, Web of Science and Scopus) that examined usability/utility of affordable exergaming technology (exclusion- fully immersive VRs) in adults with systemic disabling conditions.

4 RCTs
Few comprehensive usability assessments
Common tech- Sony PlayStation EyeToy, Nintendo Wii
8 adverse events among 346 adults
Most subjects male and s/p stroke
No focus on behavioral theories

Virtual Reality & Rehabilitation

- Meta-analysis of 5 RCTs of VR-enhanced rehabilitation for patients s/p stroke
  - High-tech gadgets such 3-D goggles, robotic gloves, and motion-tracking video game systems
  - Moderate effect sizes (0.4-0.5) with 5-fold increase in motor strength compared to those who received conventional physical therapy

Dietary Interventions Using Technology
**A Computer Support Program that Helps Clinicians Provide Patients with Metabolic Syndrome Tailored Counseling to Promote Weight Loss**

**Purpose:** To test effect of a computerized support tool to enhance brief physician-delivered healthy lifestyle counseling to patients with increased metabolic risk factors during 2 usual care visits

**Design/Sample:** CCT with 263 Hispanic adults (mean age 50 yrs), BMI >=25 from 2 large health centers

**Rx:** 12 month computer-assisted program to set weight loss and PA goals which were reviewed at clinic visits at baseline and 6 months vs usual care

**Results:** 26.3% in Rx group vs 8.5% usual care lost >5% body weight. Significant reductions also seen in LDL (-14 vs -4 mg/dL)

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**Theoretical Basis and Components of mHealth Diets**

- **Focus on Social Support**
  - Crowd sourcing
  - Cues to Action

- **Most successful**
  - Traffic Light Program

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**Traffic Light Approach**

- **Rate these foods**
- **Click on the color!**

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**Traffic Light Program**

- **Self-monitoring**
  - Diet: Crowdsourcing mobile program using pictures of meals and stoplight for rating
  - Location tracking: Tracking of time and location of eating events of red foods
- **Context-based prompting**
  - Diet: Prompting of when and where red foods are commonly consumed
  - Weight: Weekly weight (Withings scale)
  - Context: Traffic light prompting based on weight change

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**Magazine Ads Promoting Weight Management via Texting**

![Sign Up Now!](image1)

*The SELF Diet Tapper is the easiest way to get all of the great meals, moves and motivation you need to lose weight.*
Technology for health: A qualitative study on barriers to using the iPad for diet change

- 4 focus groups of university students
- Students given iPads to download diet apps
- Questions about preferences regarding iPad functionality, app functionality, use of iPad
- Themes:
  - Lack of iPad practicality
  - Inconvenient mid-way technology
  - Internet access barriers
  - Smart-phone preference
  - Attitudes towards apps
  - Too intensive
  - Positive functions not specific to iPads
  - Lack of reliable/trustworthy information

Technology Interventions: Medication Adherence

- 4 focus groups of university students
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Telephonic Counseling Using Computer Interface: OPTIMA

- **Design**: Cluster RCT of 2089 Medicare beneficiaries dx with OP randomized to either:
  - 1-year of telephone-based MI counseling (n = 1,046)
  - or a control group (n = 1,041) that received intermittent mailed educational materials.
  - 7 health educators documented calls in computer database information merged with Medicare claims

OPTIMA Results

- Medication adherence = primary outcome measured as median (interquartile range) medication possession ratio (MPR), 2nd outcomes fractures, falls
- 48% possession rate in Rx grp vs 40% in control
- No difference in fractures
- Customized computer interface easy to use and navigate by health educators

Gaming: Medication Adherence/ Self-Management- DM

- 58 children with Type I DM
- Gameboy system
- Three games:
  - Egg Breeder
  - Detective
- Access, Knowledge, Behaviors (diet, exercise), Usability, Acceptability

Assessment of Gaming Outcomes

- **Usability/Acceptability**
  - Data extraction low and high level
- **Surveys**
- **Knowledge**
- **Health-related Behaviors**
- **Health-related Outcomes**

Aoki et al, Studies Health Technology & Informatics 2004

Medication Tracking – Automated Systems

- Possible uses
  - Prompting for medications, exercise
  - Needing assistance with daily activities
  - Monitoring vital signs, blood sugar, weight, etc.
- Home PC with wireless interfaces serves as local intelligence.
  - PC gets updated instructions about client.
  - Staff use Web to retrieve, get data
  - Built-in home intelligence, daily reminders
  - Localization methods to check instruction followed

Medication Adherence: Targeting Individual, Provider & Environment

- Chart lists events
- Log kept of all events
  - Bottle taken
  - Bottle returned
  - Drawer open
  - Drawer shut
  - Inventory Update
  - Settings for inventory control

System Targets Individuals and Caregiver

- Patient interface
  - Medicine Alarm Clock
  - Prompts patient to take drug
  - Alerts if wrong medicine
  - Touch-screen
  - Enter symptoms interface
  - Forum for discussion
  - Correlate activity before/after
- Caregiver Interface
  - Records medicine use
  - Tracks over course of day
  - Keeps log of med use
  - Generates report for health care provider

Virtual Discharge Nurse and Patient Self-management

- VR Nurse
  - Reviews discharge instructions
  - Synthetic speech allows for acquisition of information with EMR
  - Avitar can assume attributes of patient
  - Promotes learning and self-management

Impact of Active Assistance Technology (AAT)

- Systematic Review of 41 articles
- Purpose: determine extent active technological capabilities of dynamic and adaptive information processing are applied in behavior change interventions and identify role of AAT
  - Active Assistance Technology - any technology involving automated processing of health or behavior change information that is ongoing as the user interacts with the technology.
  - (1) dynamic adaptive tailoring of health messages (2) interactive education (3) support for client self-monitoring of behavior change,

Dr Timothy Bickmore, Northeastern University

Kennedy, J Med Internet Res. 2012
Impact of Active Assistance Technology (AAT)

**Results:**
- Significant research on dialog systems, embodied conversational agents, and activity recognition.
- Physical Activity most covered topic.
- Most studies were early-stage research.
  - 6 RCTs, of these 4 were positive for behavior change and 1 were positive for acceptability.
- Empathy and relational behavior were significant research themes in dialog systems for behavior change.
- Few studies focused on interactive education (3) and self-monitoring (2).

**Conclusions**
- Potential capabilities and risks of AAT are not being fully explored in most current behavior change research.

Kennedy, J Med Internet Res. 2012

Telerheumatology Uses

**Strengths**
- Improved access to care
- Saves time and money
- Enhanced Communication among team (PCP, patient and Rheumatologist)

**Challenges**
- Assuring quality care
- Patient satisfaction
- Financial consideration/incentives to providers
- Medicolegal issues
- Technical Support

Roberts, Internal Medicine J, 2012

Meta-analysis of Telemedicine Rxs for Patients with Chronic Heart Failure

Clark R et al, BMJ, 2007

Summary

- Multiple factors are driving integration of technology in health
- Most published studies use web-based or texting formats
- mHealth via texting appears compatible with theories of health promotion (TPB and HBM)
  - Most mhealth in persons with Diabetes or for PA
  - mhealth interventions are not stand alone
- More positive outcomes with theory-based design and early engagement of interdisciplinary team

Summary

- Health game often integrates social support/social networks/ecological models though designs do not specify specific behavioral models
- E-communities
- Social feedback
- Partners in gaming
- VR systems can simultaneously provide motivation and ability to simulate daily activities
- Studies of health technology implementation are in the early stages, more to be discovered!
Conclusion

- Health and technology applications are on the rise.
- More likely to be adopted when has greater versatility.
- Better outcomes with behavioral theory-based interventions.
- Sometimes provides added safety benefits.
- Evolves with HP input early & often in design.

Future Implications

- Individuals with expertise in outcome assessment and behavioral science to become more engaged in design and implementation of technology-based interventions to determine impact of these programs.
- Determine which subgroups of individuals adopt and benefit technology-based interventions to promote health.

Thank you

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References

- Kato P. Video Games in Health Care: Closing the Gap. Review Gen Physiol. 2010;142(2)1113-1131.