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amin ahmadi
dave monaghan
Technology enabled behavioural change as a pathway towards better self-management of CVD
Horizon 2020, 10 partners, €4.9m, 44 months, 2015 – 2018
Coordinator - Kieran Moran
multidisciplinary research team

- bio-mechanics
- health & human performance
- preventive medicines
- medical exercise rehabilitation
- behavioural change
- computer science
- engineering
- inertial sensor analysis
- computer games development
- machine learning
- business & health economics

experts in the fields of:
motivations behind pathway

physical inactivity is responsible for:
• 5.2 million deaths (La Vecchia et al. 2012)
• 20% to 30% increased risk of all-cause mortality and Cardiovascular Disease events
• 21–25% of breast and colon cancers
• 27% of diabetes and
• 30% of Coronary Artery-heart Disease

physical activity alone
• reduces premature death by 24%
• protects from CVD risk factors and co-morbidities
• results in longer and better independent living
• decreased healthcare costs

(WHO 2011)
Cardiac Rehabilitation (CR) - essential part of the contemporary management of CVD
Phase 1: in-hospital education,
Phase 2: outpatient education and support,
Phase 3: gradual increase in supervised Physical Activity (PA),
Phase 4: community-based CR, in which patients try to sustain long-term behaviour change typically with encouragement by CR staff.

The work being done in by HeartHealth specifically targets individuals at phase 4 CR.

Community Cardiac Rehabilitation Challenges
Uptake and adherence:
- severe lack of appropriate programmes (MedEx),
- travel time, scheduling issues,
- not tailored to their needs
- lack of peer mentoring,
- low self-efficacy associated with poor exercise technique, not “wanting to fail”, perceived poor ‘body image’ (not wanting to exercise with large groups of ‘strangers’),
motivations behind pathway

end users and mocap
motivations behind pathway

end users and mocap

Lots of Equipment for one data capture
motivations behind pathway

understand the end-user and design the pathway system solely with them in mind to bring about greater behavioural change.

This image above shows a MedEx Cardiac Rehabilitation (CR) class taking place in DCU attended by over 400 Phase-4 CR patient visits a week.

utilise low-cost and accurate motion capture

replay data-capture at dcu that involved a state of the art Vicon mocap setup

we have worked to create advanced algorithms that fuse data from both the KinectV2 and body worn accelerometers, using Vicon as a Ground truth, to create low-cost accurate Mo-Cap

our sensor fusion allows us to record skeletal information with a higher accuracy than either the KinectV2 or inertial sensors independently.

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motivations behind pathway
motivations behind pathway

so what exactly do you want to do?

we want to use low-cost motion capture technologies coupled with computer gamification, patient information managements systems and effective behavioural change
to
develop a low-cost, home-based, self-selected, personally tailored, continually challenging and enjoyable, CVD exercise-based rehabilitation and monitoring platform
to
courage patients to self-manage their CVD through exercise and physical activity
THE HYPER-CONNECTED PATIENT
New opportunities to manage and prevent chronic diseases

PREVENT CHRONIC DISEASES AND THEIR COMPLICATIONS
Europe has the highest burden of chronic diseases globally\(^1\)

90% of all deaths in Europe are caused by chronic diseases\(^2\)

86% are caused by:
- diabetes
- cardiovascular diseases
- cancer
- chronic respiratory diseases
- mental disorders

BY 2017
5 million patients worldwide are forecast to be using wearable technology and remote monitoring devices\(^3\)

Patient generated data can be shared with healthcare providers and social networks to:

Support Healthcare Costs Sustainability
Enhance Chronic Disease Management
Reinforce Healthy Lifestyles

Secure access to information needed for the lifetime of the patient
A patient centered ecosystem relying on end-to-end information management
An interoperable, agile architecture that is sustainable as technology changes

Engage the Patient in the Delivery of Integrated Care
It's more than just devices. It's about:

57% willing to use a device if it would lead to lower health insurance premiums\(^4\)

40.9% lost interest and stopped using devices when no behavioral change programs were used\(^5\)

COM-B: A simple model to understand behaviour...

- **Capability**: Psychological or physical ability to enact the behaviour
- **Motivation**: Reflective and automatic mechanisms that activate or inhibit behaviour
- **Opportunity**: Physical and social environment that enables the behaviour
• Technology Usage Questionnaire
• End-user Interviews
Results

• 298 respondents
  – 70 Heartsmart Dublin
  – 129 Harpa Leuven
  – 56 hospital based CR Leuven
  – 43 congenital heart disease consultation Leuven
Mobile phone use

97% has mobile phone

smartphone (58%)

mobile (42%)

Phase 3
Phase 2
ACHD

calls
texts
photo/video
internet
apps
IM
social networks
games
Internet use

91% has regular internet access

- 76% use internet every day
- 17% use internet 3 times/week
- 4% use internet 1/week
- 3% use internet <1/week

Devices:
- Computer
- Tablet
- Smartphone

Phases:
- Phase 3
- Phase 2
- ACHD
Interested in receiving CR support via mobile phone/internet?

- Yes (68%)
- No

- Yes (77%)
- No

Bar charts showing distribution of responses across different channels:
- Texts
- Video
- Apps
- Internet
- Emails
- Videos
- Websites
- Leaflets
Are you aware of computer based physical activity games?

- never used an exergame (78%)

- Phase 3
- Phase 2
- ACHD

[Bar and Pie Chart showing awareness and usage of exergames]
Would you think that a virtual rehabilitation class would be useful?

- 32% sounds appealing
- 26% will definitely engage
- 20% prefer to do it on my own
- 22% sounds unappealing
Overall interest in PATHway

(mobile, internet, computer game, virtual environment)
## How useful would the following advice be?

<table>
<thead>
<tr>
<th>Advice</th>
<th>1 (Not at all useful)</th>
<th>2 (Somewhat useful)</th>
<th>3 (Very useful)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise ideas</td>
<td>11</td>
<td>5</td>
<td>19</td>
</tr>
<tr>
<td>Exercise prompts</td>
<td>15</td>
<td>9</td>
<td>26</td>
</tr>
<tr>
<td>Exercise programme taught by a virtual coach (via the internet)</td>
<td>21</td>
<td>10</td>
<td>22</td>
</tr>
<tr>
<td>Information on local exercise opportunities</td>
<td>10</td>
<td>9</td>
<td>24</td>
</tr>
<tr>
<td>Healthy meal ideas and recipes</td>
<td>9</td>
<td>9</td>
<td>20</td>
</tr>
<tr>
<td>Practical ideas to manage stress</td>
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<td>9</td>
<td>21</td>
</tr>
<tr>
<td>Setting goals</td>
<td>16</td>
<td>9</td>
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<tr>
<td>Steps to achieve goals</td>
<td>17</td>
<td>8</td>
<td>27</td>
</tr>
<tr>
<td>How to remember to take your medications</td>
<td>37</td>
<td>9</td>
<td>17</td>
</tr>
<tr>
<td>Healthy eating tips for takeaways and dining out</td>
<td>21</td>
<td>9</td>
<td>21</td>
</tr>
<tr>
<td>How to link up with others who are living with heart disease</td>
<td>22</td>
<td>14</td>
<td>31</td>
</tr>
</tbody>
</table>
WHERE ARE EUROPEANS Active?

European Week of Sport

- At home: 36%
- At work: 13%
- At a sport club: 13%
- In a park, outdoors: 40%
- On the way between home and school, work or shops: 25%
- At a health or fitness centre: 15%

#BEACTIVE
Behavourial change: Key Objectives

1. bring together patients, exercise specialists and clinicians to **identify** and **collaboratively** define the exercise, health and referral content for PATHway

2. manage ongoing engagement and consultation with **stakeholders** (health workforce) to ascertain their opinions on how best to **effectively implement** PATHway within the health care and community settings
CVD Patients

1. Help CVD patients to express their own experiences related to exercise, PA and SB.

2. Help CVD patients to express their needs and wants towards (PATHway) intervention to change specific health-enhancing exercise, PA and SB.

3. Identify CVD patients’ needs and wants from a technology-based intervention.
Patient 1-1 Interviews

- Ethical approval
- TUQ: high, moderate and low tech interest/use
- In-depth 60 minute interviews
Our participants

- 42 patients recruited
- 42 patient interviews ✓
  - Phase 4 attendees
  - Phase 3 attendees
  - Phase 4 dropouts
  - Phase 3 non-completers
Preliminary Data Analysis

• Main barrier - **Motivation**
  • (goal setting/monitoring key to PATHway success)

• Needs to be **easy to use**, potentially have **IT support**

• Preference for **Active Lifestyle** among low tech users

• Want **PATHway to augment existing networks**, do not want PATHway to replace traditional Phase 4 classes (e.g., HeartSmart)

“If your typing slows down, the special ergonomic keyboard injects coffee directly into your fingertips.”
Preliminary data analysis

• Social connection with other CR patients is key to CR adherence and enjoyment
• Want demonstrations and training with PATHway
• Liked idea of wrist worn sensor
  • Phase 4 patients felt zensor ‘too medical’
  • Phase 3 patients like the security of being ‘monitored’
• Raises issues regarding confidence, illness perceptions, will data be monitored
• Some participants wanted wrist worn sensor to be waterproof
Stakeholder Interviews
Key Stakeholders

1. To explore opinions and preferences for the **most appropriate content and most viable approach** for delivery of the PATHway intervention
2. Explore strategies for **recruitment and retention** of study participants.
3. Explore strategies for **treatment adherence**
4. Explore strategies to **overcome barriers** to the acceptability of the intervention in the proposed study.
Recruit Key Stakeholders

Chief of the cardiology department (1), CR cardiologists (2), adult congenital heart disease cardiologist (1), hypertension specialist (1), vascular surgeon (1), specialized CR nurses (4), CR physiotherapists/exercisephysiologists involved in phase 3 and 4 (4), CR psychologist (1), GPs (3), social workers (2), local patient organisation (1), technologists with experience of healthcare devices in cardiac rehabilitation (1), the Irish Heart Foundation (1) and the Irish Association of Cardiac Rehabilitation (2)
Recruitment (20 participants)

**Public Policy Level:**
- Department of Health
- Health Service Executive

**Organisational Level:**
- Cardiac Rehab Nurses
- Cardiologist
- Health psychologist in CR
- Hypertension specialist
- Physiotherapist
- Cardiology technician

**Community Level:**
- Irish Heart Foundation
- General Practitioner
- Patient advocacy group
Preliminary data analysis

• Main target should be **GPs but patient led.**
• Needs easy to read **printable summaries** (graphs etc.)
• **Emergency protocol** needs to be in place in case of adverse events (e.g., emergency services numbers provided)
• **Issues for implementation/ sustainability**
  • **Staffing**
  • **Space** (motion capture sensors working accurately within a busy room)
  • Needs to have **variety** for patients within exerclass / exergame
  • Needs ‘**buy in’ from senior staff** and be promoted as the key to Phase 4 throughout team and hospital based CR
  • **Buy in comes with evidence based outcomes** and if patients enjoy using Pathway.
next steps for behavioural change...

✓ Development of behaviour change content
✓ Formative testing of PATHway content

1. Focus groups with CVD patients (N= 12 FGs)
   • How to incorporate PATHway in daily lifestyle?
   • What functions they find useful?
   • Strategies to maintain engagement with PATHway?

2. Steering committee review (Stakeholder Expert Panel)
   • Review existing content
   • Review theoretical basis and logic behind PATHway prog.
   • Agreement on key PATHway components and functionality
RePLAY: Digitally Capturing Unique skills in European Traditional Sports and Games
(FP7, ICT-2011.8.2 : €2m, 8 European partners)
• “Traditional Sports and Games (TSG) are part of Intangible Heritage and a symbol of the cultural diversity of our societies” (UNESCO, 1989)

- Only in Europe, there are over 3000 Traditional Sports and Games
- Many Traditional Sports and Games are already lost or in danger of disappearing
  - Globalization by a few sports
  - Increased tendency towards individual physical exercise
What is RePlay

Understand, preserve and promote Traditional Sports and Games

• RePlay is a €2million research project funded by the EU Framework Program 7 (FP7)
• RePlay will develop a low-cost technology platform to access and interpret digital content for Traditional Sports and Games
  ▪ Selection of Sensors and low-cost capture technologies for 3D sports content
  ▪ analysis and modeling of performance skills
  ▪ 3D rendering and visualization of motion capture data
• RePlay will select several modalities from Basque Pelota and Gaelic Sports as representatives of Traditional Sports and Games
• The project started on the 1st of March 2013 and will last for 36 months (Until the end of February 2016)
• COACH&TRAIN scenario
  - Hardware
    - Four Microsoft Kinects
    - Nine Shimmer3 WIMUs
• The RePlay platform relies on fused skeleton combining the Microsoft Kinect and WIMUs
  ▪ The platform extracts one skeleton of reference from the Microsoft Kinect device
  ▪ Local orientations over time are extracted from the WIMUs

• The fused skeleton is the combination of the reference skeleton and the rotations
Fused skeleton

Kinect One  Fusion  Kinect Two
Fused skeleton

- Animation of the fused skeleton from a reference
Full Body 3D Reconstruction
Feature extraction

• Feature extraction
  ▪ Accurate motion features are essential, as they will be used for the scoring system and the semantic feedback
    • Joint’s relative positions (to the root joint)
    • Joint’s hierarchical rotations (with respect to their parent joint rotation)
    • Joint’s linear velocity
    • Joint’s angular velocity

• Flexion
• Extension
• Adduction
• Abduction
• Linear kinetic energy of each joint
Skill synchronization

• The DTW technique is applied without constrains to align the trials globally and offer the temporal warping
• Joints information are combined using the weights of importance defined by experts

“Right-Handed Underarm Shot” (Handball Sport)

Y component of the wrist position. The green is the reference activity, the orange one is the user’s recording activity.
Skill comparison

• Skill evaluation
  ▪ It follows a weighted scheme
  ▪ Pre-defined weights for every sport action have been assigned on the basis of specific teaching points

Hurling – Strike from the Hand

<table>
<thead>
<tr>
<th>position</th>
<th>angle</th>
<th>linear vel</th>
<th>angular vel</th>
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<tbody>
<tr>
<td>Head</td>
<td>1</td>
<td>0.1</td>
<td></td>
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<tr>
<td>Trunk</td>
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<td>0.6</td>
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<td>R_Hip</td>
<td></td>
<td></td>
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<tr>
<td>R_knee</td>
<td></td>
<td>Flexion - extension</td>
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<td>R_ankle</td>
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<td>R_Elbow</td>
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<td>1 Flexion - extension</td>
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<td>0.3</td>
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Measured relative to the global coordinate system (intended direction of strike)
• COACH&TRAIN scenario
Feedback return
Rendering and Visualization

• 3D reconstruction of the appearance of the National/Local Heroes component
  § Template avatar
    • A template avatar has been designed
    • A customized avatar has been created for each disciplines
      – Clothes
      – Accessories
Rendering and Visualization

• 3D reconstruction of the appearance of the National/Local Heroes component
  ▪ Image based 3D scanner
    • A low cost 3D scanner has been built in order to create an accurate 3D avatar of the National Heroes
    • 81 compact cameras are synchronized
    • Photogrammetry technique is used for 3D reconstruction
What has been achieved?

• Dynamic animation viewer to visualize the activation of the targeted muscle during the animation
RePlay Platform

Digitally capturing unique skills involved in European Traditional Sports and Games
….. thanks for
listening

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