PATHway: Decision Support in Exercise Programmes for Cardiac Rehabilitation

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DSS – Design cycles

- Requirements gathering
  - Standard clinical recommendations and guidelines
  - Empirical knowledge

- Rules formulation
  - Coding of the requirements
  - Deterministic rules in the format of condition-action (IF-THEN)

- Review rules
  - By the clinical expert

- DSS implementation
  - Rules programming
  - Data representation
  - Development of communication interfaces

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DSS components

Home DSS (short-term decisions)

• Prescreening
  – Check the patients’ health status before starting an exercise session

• Real-time
  – Adjust the exercise session according to the patients’ performance
  – Motivation

Off-line DSS (long-term decisions)

• Evaluation of the whole exercise session
• Personalization of the CR programme according to patient performance, compliance and preferences
• Motivation

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<table>
<thead>
<tr>
<th>Rule Description</th>
<th>Condition</th>
<th>DSS action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prescreening</strong></td>
<td>Rule for checking if the patient didn’t eat during the last 4 hours AND vital signs measurements are OK</td>
<td>If answer to question about eating during the last 4 hours, is NO AND systolic BP&lt;180 AND HRrest &lt;75% HRmax</td>
</tr>
<tr>
<td><strong>Real-time</strong></td>
<td>Rule for progressing to an exercise with higher intensity</td>
<td>If accuracy is medium/high AND [(HRmean&lt;B) OR (HRmean&gt;B AND HRmean&lt;C AND slope&lt;W1) OR (HRmean&gt;C AND HRmean&lt;D AND slope&lt;W1)]</td>
</tr>
<tr>
<td><strong>Offline</strong></td>
<td>Rule for excluding specific exercise when HR value is high for more than 3 consecutive appearances of the exercise.</td>
<td>If exercise consecutive appearances &gt;= 3 AND mean HRmean&gt;F for the aforementioned sessions</td>
</tr>
<tr>
<td><strong>Offline</strong></td>
<td>Rule to motivate patient when he/she is on track to meet the weekly goal near week’s end</td>
<td>If (time is end of day 5 of the weekly exercise programme) AND SUM (session_durations) &gt; 50% of weekly physical activity goal</td>
</tr>
</tbody>
</table>
DSS architecture

• Using Python programming language
  – multiplatform
  – rapid prototyping
  – good performance

• RESTful web-service with specific end-points
  – Service Oriented Architecture
  – Built using web.py python library
  – Synchronous communication

• JSON serialization
  – Input validation using JSON schema

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Home DSS prototype implementation

• Example rule for progression to an exercise with higher intensity

Input JSON object

```json
{"targetHRzone": {"high": 90, "low": 70}, "exerciseCumulativeAccuracy": 0.65, "targetAcczone": {"high": 0.7, "low": 0.5}, "vitalSigns": {"hr": [65, 62, 64] }}
```

DSS response

```json
{"result": "progression", "description": "While you performed the exercise correctly, your heart rate is still low. Let's move one level up now!"}
```

<table>
<thead>
<tr>
<th>Hear Rate</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOW</td>
<td>LOW</td>
</tr>
<tr>
<td>NORMAL</td>
<td>MEDIUM</td>
</tr>
<tr>
<td>HIGH</td>
<td>HIGH</td>
</tr>
</tbody>
</table>
Home DSS Rules Evaluation Study

- **Target:** 15 CVD patients, 45 exercise sessions by **July 15th**
  - 10 patients have already been recruited (18th May)

- **Environment:**
  - 3 Public Gyms
  - Sessions monitored during standard exercise programmes for people with CVD conducted together with **specialised trainer**

- **Data collection:**
  - **Motion** (Microsoft Kinect camera)
  - **Heart rate** (Scosche wristband sensor)
  - **ECG, Breathing Rate, Activity** (Zephyr BioHarness)
  - **Resting Heart Rate, Blood Pressure**
  - **Questionnaires** (pre-screening, enjoyment, RPE, etc.)

- **Data Processing:**
  - Processing of Motion Recordings
  - Evaluation of Rules based on Accuracy, Heart Rate Intensity & other collected data

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Home DSS Rules Evaluation Study

Goal: Check the validity of the rules

- Which is the accuracy/HR variability when performing the same exercise in different time frames?
  - How to extract the accuracy zones (low/medium/high)?
  - How to calculate personalized parameters?

- How patients’ heart rate/accuracy varies during the execution of different activities?

- Which is the association between the answers to the exertion/enjoyment questionnaire and the observed characteristics (accuracy/HR)?

- When to exclude an exercise from the patient’s exercise programme?
Home DSS Rules Evaluation Study

Wristband
HR sensor
ECG, Breathing Rate & Activity Chest strap

Wristband
HR sensor
ECG, Breathing Rate & Activity Chest strap

Kinect camera
Markers for motion recognition

Laptop & smartphone for collection of recordings

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Future work

– Prediction of compliance

– Tailoring of health behavior goals
  • associate health, psychological, behavioral, and social activity data to provide patients with personalised information

– Evaluation by clinical experts in a 6-month randomised controlled trial with CVD patients

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Thank you

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