Multi-scaled assessment for predicting pain experience in adolescents with Sickle Cell Disease

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SICKLE CELL DISEASE

- Sickle Cell Disease (SCD) is a genetic blood disorder.
- Changes in hemoglobin cause the stiffening and distorting of red blood cells into the shape of ‘sickles’.
- Sickled red blood cells restrict blood flow to different parts of the body.
- This anoxia causes acute pain episodes (APE) that can lead to damage to organs (heart, brain, lungs, spleen) as well as muscles and bones.

ACUTE PAIN EPISODES

- During an APE, sickled red blood cells restrict blood flow to different parts of the body, leading to Vaso-occlusion.
- The result is prolonged lack of oxygen to parts of the body near the vaso-occlusion, which can organ (heart, brain, lungs, spleen) as well as muscles and bones.
- APE can occur quickly, without warning and in some cases result in permanent damage or death.

SCD PAIN

- Individuals with SCD experience chronic pain in addition to APE, which can be intense and debilitating. (Dampier et al., 2017)
- The mechanisms of SCD pain are complex and not well understood. (Dallas, 2011)
- Pain experience is extremely variable both within and across patients. (genetics, location, frequency, severity, age and co-morbidities, i.e. depression + asthma). (Smith et al., 2009, McClain et al., 2008)
- SCD patients often manage their pain at home, and avoid seeking medical care because they have negative interactions with health care staff when seeking pain relief in the ER. (Jennerett & Bresser 2010)
- Avoiding medical assistance can have substantial consequences, particularly when pain episodes become life-threatening.
- Additionally, permanent damage caused by ACE can further exacerbate chronic pain.

OBJECTIVES

- Provide support for the large number of SCD patients managing their pain at home.
- Help understand and anticipate vulnerability to acute pain episodes.
- Contribute to a better understanding of the chronic pain experienced by individuals SCD.

PROJECT AIMS

- Capture both active and passive measurements during pain experience outside the clinical setting.
- Assess changes in dynamics of these measures across different reported pain intensities.
- Identify measures that can serve as indicators and/or predictors of pain intensity and the onset of severe pain events.

PARTICIPANTS

- Four young adults with Sickle Cell (SCYA) recruited from Cincinnati Children’s Hospital Medical Center (CCHMC).
- 2 males, 2 females, all age 20, African American.
- 3 with genotype HbSS, one with HbSC.
- All considered to have a “severe” disease condition. (Parapito et al., 2013)

<table>
<thead>
<tr>
<th>SCYA 1</th>
<th>SCYA 2</th>
<th>SCYA 3</th>
<th>SCYA 4</th>
</tr>
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<tbody>
<tr>
<td>Hospital Admissions</td>
<td>6</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>ED Visits</td>
<td>8</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>ACS Diagnosis</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Stroke</td>
<td>No</td>
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<table>
<thead>
<tr>
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<th>Diary Start</th>
<th>Diary Length</th>
<th>Pain Rating</th>
</tr>
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<tbody>
<tr>
<td>6/28</td>
<td>9:30 AM</td>
<td>90 min</td>
<td>6</td>
</tr>
<tr>
<td>6/28</td>
<td>9:30 AM</td>
<td>90 min</td>
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<tr>
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<tr>
<td>6/29</td>
<td>3:57 PM</td>
<td>8:00 PM</td>
<td>90 min</td>
</tr>
</tbody>
</table>

MEASURES

- ACTIVE
  - Pain Intensity (alarming scale 1-10)
  - Pain location (draw on body diagram)
  - Pain descriptors (flat + write in)
  - Word (“Happiness”)
  - Stress (alarming scale 1-10)
  - Fatigue (alarming scale 1-10)
  - Notes (medications)

- PASSIVE
  - EdA (skin conductance): 4 Hz
  - ST (skin temperature): 4 Hz
  - ACC (accelerometer movement): 32 Hz
  - Weather (temperature, cloud coverage, wind, precipitation, humidity, & air pressure)

STRESS AS A PROXY

A combination of software and wearable sensors have demonstrated the ability to identify stress with 90% accuracy (Ekman et al., 2014).

For some patients, stress was significantly correlated with pain intensity, thus stress detection may be a helpful starting point.

KEY FINDINGS & EVALUATION

- Data pre-processing included down-sampling, calculating means, standard deviations, recurrence analysis measures, and detrended fluctuation analysis.
- Data were subjected to linear mixed models with random slopes and intercept, as well machine learning using ten-cross validation with linear regression, multi-level perception, and random forest.

However, identifying predictive relationships between the physiological signals and pain experience that are clinically relevant will require the following:

1. Sophisticated sensors and/or filtering techniques to identify and remove movement artifacts from the skin conductance and BPV signal.
2. Higher resolution in the reports of pain experience, i.e. more moment updates so the dynamics can be captured in enough detail.

FUTURE DIRECTIONS

- Initial understanding of the relationship between physiological signals and pain intensity could be captured when SCD patients come to the hospital for an ACE.
- Use similar mobile interfaces, but adapted so they click either a plus or minus when they experience changes in pain intensity (Figure 2).
- This could help predict the onset of a secondary complication, acute chest syndrome while in the hospital (Barolet et al., 2015), as well as develop methods to predict ACE in home settings.

REFERENCES

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ACKNOWLEDGEMENTS

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Figure 1: Screenshots of the Empatica wristband application the patient will use to report their pain experiences.

Figure 2: Flowchart that pain changed periodically passed through both SCYA 3 and SCYA 4.