Background

- Sickle cell disease (SCD) is an inherited red cell disorder that is typically complicated by painful vaso-occlusion, the most common cause for hospitalization.
- Studies to determine if mobile technology improves outcomes and patient experience in hospitalized patients has been limited.
- Wearable sensor based health monitoring systems are experiencing rapid growth, motivated by increasing healthcare costs and the possibility of generating personalized health management.
- Our novel TRU-Pain system (Technology Resources to better Understand Pain) combines mobile apps with wearable technology to improve measurements of subjective (such as pain) and objective data (such as heart rate and activity).

Objectives

- Leverage mobile technology and wearable technology to provide quantitative evidence of both pain scores and physiologic data.
- Use statistical analysis and machine learning to map the patients’ physiologic information with their pain scores as a mean to assist with documentation of pain, interventions, and general health.
- Supply subjective reports of pain with objective measurements to better predict pain.

Data

- Mobile application (TRU-Pain mobile app):
  - Patients recorded symptoms daily including pain, other symptoms and general health using the TRU-Pain app up to 7 days while hospitalized.
- Wearable device (Microsoft Band 2):
  - Objective data including heart rate (HR), activity (steps), galvanic skin response (GSR), barometer, and ambient light.
- Electronic medical record (EMR):
  - Pain and six vital signs recorded were used as the gold standard for validating the accuracy of physiological data measured from wearable sensors, as well as the data for pain prediction.

Methods

- Statistical analysis:
  - Multiple group of Pearson’s correlation were examined: among symptoms in app data, between heart rates in wearable data and EMRs data, between pain scores in app data and EMRs data.
- Machine learning technique for pain prediction:
  - Multinomial logistic regression (MLR), support vector machines (SVM), k-nearest neighbors (KNN), and random forest (RF) were applied to predict visual analog pain scores (0-10), using six vital signs from EMRs.

Results

- We enrolled 20 patients with SCD who were admitted for a median 5 days (range 2 to 8).
- Patients used TRU-Pain app throughout hospitalization and made entries between 0 to 2 times per day.
- The wearable sensor collects data every second. The median amount of data collected is 10930 points (range 21 to 54693) per day. The median amount of hours of wearable data is 4.21 hours (range 2 minutes to 18.05 hours) per day.
- Heart rate records with the wearable sensors were found to be highly correlated ($r = 0.69$, $p < 0.005$) with heart rates in EMRs.
- Pain scores recorded with the TRU-Pain app were found to be highly correlated ($r = 0.74$, $p < 0.005$) with pain scores in EMRs.
- Using objective physiological measures from EMRs, pain scores on an 11-point rating scale can be predicted with an average accuracy of 0.578 at the intra-individual level, and an accuracy of 0.429 at the inter-individual level using Multinomial Logistic Regression (MLR).
- With a condensed 4-point rating scale (none/mild/moderate/severe), the accuracy at the inter-individual level was further improved to 0.681.

Discussion & Future Directions

- We successfully collected data via our mobile application and wearable device.
- Subjective data such as pain and objective data such as heart rate can be tracked using mobile and wearable technology in an effective way, but requires a balance between quantity of data acquired and battery life.
- Our study shows the feasibility of using mobile and wearable technology to help predict pain, track sleep and improve care patients with sickle cell disease.
- We aim to next use objective physiological data measured via wearable devices and subjective patient reports via our TRU-Pain app to construct a real time pain prediction model. Such a system can help clinicians with clinical decision support such as medication dosage and frequency.

Pearson’s correlations between symptoms in app data

- Pain Prediction Accuracy Results

- MLR
- SVM

- Intra-Individual model performance
- Inter-Individual model performance

References


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Conflict of Interest Disclosures

Nirmish Shah – Speaker, Novartis; Jude Jonassaint – officer, Sicklesoft; Remaining authors have no relevant conflicts of interest to disclose.