Clinical Perspective

Pain and fatigue (both chronic and acute) are two of the most prevalent and impactful symptoms experienced by patients afflicted with a wide range of common diseases and rare disorders. It is estimated that 10% of the world’s population is affected by chronic pain, disproportionately adversely affecting disadvantaged individuals, resulting in an enormous cost to society [1]. Fatigue is a regular complaint, with a reported prevalence in the general population ranging from around 6 [2,3] to 38 percent [4]. One study estimated that the annual cost to employers in lost productivity due to fatigue exceeds $136 billion [4]. Twenty-one to 33 percent of patients report significant fatigue when visiting a primary care physician [5-9], resulting in approximately 7 million office visits per year in the United States [10]. Moreover, the recognition of fatigue in healthcare providers and adequately addressing this issue is critically important to the assurance of optimal patient care.

Of course, as any medical or graduate student can attest, fatigue impacts a much broader population cohort than patients and caregivers, as does pain. And the two are often linked, with fatigue leading to pain and injury, and pain causing fatigue and exhaustion, in a vicious cycle. Commercial drivers and pilots, laborers and factory workers, soldiers and law-enforcement agents, professional athletes and weekend warriors..., indeed, much of the human population would benefit from real-time, personalized monitoring, assessment, and management of pain and fatigue to improve performance, avoid accidents, and stay healthy.

Currently, largely subjective tools are employed to describe pain intensity and fatigue. Few objective tools to measure, quantify, monitor or track these symptoms exist. No rapid decision analysis tools are available to capture symptom burden and to appropriately guide and optimize choices of intervention.

Furthermore, there is growing concern about the overuse and abuse of prescription pain medications. Rates of opioid addiction are staggering. In one estimate, 1.7 million Americans age 12 and older abused pain medications in 2007 [11]. In a 2014 address to the Senate Caucus on International Narcotics Control, Nora D. Volkow, MD stated “It is estimated that between 26.4 million and 36 million people abuse opioids worldwide, with an estimated 2.1 million people in the United States suffering from substance use...
disorders related to prescription opioid pain relievers in 2012 and an estimated 467,000 addicted to heroin” [12]. Cost effective and feasible alternatives to pharmaceutical interventions for the treatment and management of pain are critically needed.

**SINAIMedMaker Challenge Solutions**

These problems related to pain and fatigue can be addressed by the following technology solution categories in the context of the SINAIMedMaker Challenge:

- Assessment and Characterization Tools
- Tracking and Monitoring Devices/Platforms
- Decision-making and Management Apps
- Therapeutic Apps and Devices

Each of these is described briefly below, with a few examples of possible solutions to help stir the imagination.

**Assessment and Characterization Tools**

Technology can be used to facilitate the implementation of an objective fatigue or pain scale, by streamlining the collection and analysis of a range of quantitative physiologic fatigue- and pain-related metrics. Additionally, it could be useful to implement an objective way to characterize more nuanced aspects of pain using more than a single intensity scale, paving the way for more accurate diagnosis of type and source of pain, and objectively assessing the efficacy of therapeutic intervention.

**Examples:**

- Sensors and software algorithms that can objectively distinguish “aching” vs. “stabbing” vs. “throbbing” pain characteristics
- Apps that can adapt to create a personalized pain/fatigue-intensity monitoring tool, by correlating sensor data with subjective self-assessment of pain/fatigue to train the app using machine learning algorithms
- Sensors and imaging tools to quantify biophysical indicators of pain and fatigue, such as EMG, EEG, facial expressions, body motion, etc.
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Tracking and Monitoring Devices/Platforms
Technology to monitor fatigue or pain through indirect measures of other symptoms and biomarkers that could be indicative of pain or fatigue.

Examples:
- An array of pain intensity sensors to identify a pain epicenter and pinpoint a site of origin
- Tracking physical activity levels using activity monitors and/or apps over time and predicting fatigue
- Devices that measure physiological data linked to pain and fatigue, such as sweat, EEG, muscle activity, eye-blinks, posture, etc.
- Platforms that detect and recognize fatigue and pain from real-time patient data streams
- Low-cost blood tests (or sweat, tears, urine, saliva) that measure biomolecules that could be markers of pain and fatigue onset and severity
- Big data analysis of electronic medical records that could reveal clinical measures not previously correlated with chronic pain and fatigue
- Apps that track patient and/or healthcare worker sleep patterns, activity, and behavior when interacting with an app.

Decision-Making and Management Apps
Apps to help people record symptoms and manage chronic pain and fatigue over time, as well as platforms for caretakers to view patient data and manage patient care, track outcomes, etc. Although this is already an active area, a recent review describes 220 pain-related smartphone apps (Wallace and Dhingra, *Journal of Opioid Management*, 2014), highlights the density of this space. However, creative, effective tools are still needed.

Examples:
- Cloud platform and app for tracking patient-reported outcomes and reducing readmissions due to chronic pain and fatigue
- Apps for pain/fatigue based journaling and self-surveying, to monitor and improve sharing of pain data between patient and doctor
- Apps to assist in predicting adverse drug interactions for patients with complex disease and pain management therapies
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- Strategies to simplify the clinical trial process for easier objective assessment and validation of pain/fatigue technologies
- Apps to simplify and improve inclusive recruitment of diverse patient populations in pain/fatigue-related clinical trials

Therapeutic Apps and Devices
Non-drug based interventions for treatment of acute or chronic pain and fatigue, including devices that create analgesic effects or counter the cause of certain types of pain or fatigue directly. The devices can be specific to certain areas of the body and/or different types of pain or fatigue. Also can be apps that modulate behavior to reduce pain and fatigue

Examples:
- Biofeedback tools for treating pain
- Tools to guide patient diet or lifestyle to reduce pain and fatigue
- Light-therapy approaches for treating pain and fatigue
- Electrical stimulation devices to treat peripheral nerve pain

References: