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Identification of acute pathological heart rate variability variance using wearable technology and novel predictive software: A multi-disciplinary collaboration between St Luke's Rehabilitation and Eastern Washington University

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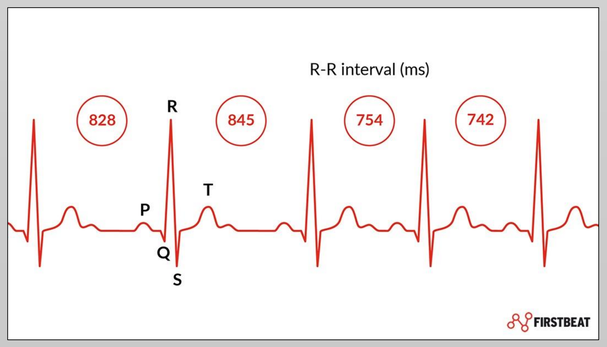
Brief Overview

The goals of this presentation:
1. Present a common problem experienced by residents and anyone attempting to perform complex multi-disciplinary research at a non-academic medical center.

2. Present an effective solution to this problem with emphasis on residency programs in Spokane.

Problem:
We had an idea for a pragmatic and novel intervention for a relatively common problem in our population and in the general public, however due to the complexity of the project and lack of resources available at a non-academic center the task became daunting.

Solution:
Through networking, we created a multi-organizational and multi-departmental collaboration between EWU computer sciences department students and faculty, the EWU Health and Wellness Sciences department faculty, St Luke's Cardiac Rehab., St. Luke's Rehab. Psychology, St. Luke's Brain Injury department, and St. Luke's PM&R residency.



Background

- **HRV (heart rate variability):** a series of mathematical calculations derived from the variation between consecutive heart beats, termed inter-beat-intervals (IBI).
- **Relevance:** Embedded within the complex oscillating IBI pattern is information about sympathetic activity, parasympathetic activity, baroreceptor activity, enhanced cognitive processing, respiratory sinus arrythmia, and vagal tone 1,2
- **Application:** HRV and further data extrapolated from HRV based calculations have been used for prognostic, diagnostic and therapeutic means in a variety of disease states3–10. Most commonly HRV is used as a marker of cardiac and general health, yet many pathologic states have been shown to cause decrease in HRV via increased sympathetic tone 5,9,11–17.
- **Interventions:** HRV optimization through biofeedback has been applied to improve cognition in multiple domains, improve exercise performance, improve emotional state and multiple other variables that contribute to decreased functional states18–20.
- **Calculation:** The gold standard for HRV calculation is derived from EKG monitoring, however multiple wearable devices have been validated to reliably calculate HRV; traditionally over a 24 hour interval.
- **Novelty:** An alternative application may be the use of serial short-term HRV (~5 minutes) to predict acute increase in sympathetic activity, however this has traditionally been logistically difficult to obtain due to requirement of EKG ambulatory monitoring.
- **Approach:** Wearable HRV calculation is a pragmatic approach that provides real-time, high-volume monitoring of data with the potential for real-time interventions when HRV is decreased. Multiple devices have been validated to reliably calculate HRV
- **Importance:** Stress and agitation (both sympathetically driven) are common and costly, particularly in some vulnerable populations. However, they are often not recognized until stressor has passed. The authors are hopeful that serial short-term HRV measurement has become technologically feasible, however this software is not readily available for wearables to the authors best knowledge. The goal of this project is to harness available technology to provide intrusive feedback and qualitative input to optimize outcomes.
- **Limitations:** A device and software must be capable of this increased frequency of data collection, removal of interference and false signals, interpretation of the data collected, and identification of pathophysiologic variance vs normal physiologic changes.

Introduction

Overall Goal:
Identification of acute pathophysiologic heart rate variability variance using serial short-term HRV as measured by temporal domain measures, collected and interpreted via novel predictive software on a wearable device, in order to prevent/abort episodes of inappropriately elevated sympathetic tone through biofeedback mechanisms.

Interpretation: Goal to identify abnormally decreased HRV specifically caused by increased sympathetic tone using novel predictive software on an Apple Watch, when measured in 5 minute rolling windows. Plan to then intervene during or prior to an increased sympathetic state using prompted biofeedback, such as specific breathing techniques which have been validated in this manner.

Methodology/ Collaboration

Due to the complexity and multi-disciplinary requirements of conceptual design, software design, data collection/ validation, statistical analysis, and access to pertinent populations a multi-organization, multi-departmental and multi-disciplinary approach was required.

1. Conceptual design: St. Luke's Rehabilitation Psychology, St Lukes Brain Injury Department and residency.
2. Software design: St. Luke's and EWU computer sciences students and faculty
3. Data Collection/Validation: St. Luke's and EWU Department of Wellness and Movement Sciences via Athletic Training and Exercise Science
4. Statistics: EWU Department of Wellness and Movement Sciences
5. Initial Application: EWU student-athlete population

After validation goal for multiple concurrent arms in different populations, utilizing the access to multiple distinct populations via a St Lukes/EWU collaboration.

Potential Applications: TBI and PTSD agitation treatment/prevention, monitoring and manipulating preperformance stress in non-injured athlete population, pre and post concussion investigation, among others.

Conclusion

This project is pertinent to the innovation in medical education category due to extensive interdisciplinary collaboration required. This project takes advantage of the rich academic environment present in Spokane, and has established an avenue of collaboration between the EWU computer sciences department students and faculty, the EWU Health and Wellness Sciences department faculty, and St Luke's Cardiac Rehab., Rehab. Psychology, Brain Injury department and St. Luke's PM&R residency.

This project serves as a proof of concept to address the difficulty of undertaking multidisciplinary research at a non-academic medical center through outreach to local academic institutions.

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