Neuromuscular Stimulation and Musculo-Skeletal Disorders: A Technology Approach to Prevention and Intervention in Workers

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Overview

• Background
  ▪ Musculoskeletal Disorders
  ▪ R&D Focus: what areas most benefit workers?

• Technology Discussion
  ▪ Neuromuscular Stimulation
  ▪ Traditional techniques vs. Sigma Q technology approach

• Potential applications

• Research ideas on the horizon

• Wrap-up and Summary
Musculo-Skeletal System in Motion

- Movement involves complex nervous system interaction with muscle tissue
  - Neuromuscular junctions
  - Feedback loop
- Signal interactions from brain and spinal cord
  - Lower motor neurons – coordinate from spine to muscles
  - Upper motor neurons – regulate messages from lower motor neurons at higher level
In skeletal muscle, a nervous impulse releases acetylcholine at the NM junction, creating an action potential and leading to contraction.
Musculoskeletal Disorders

• Musculo-skeletal disorders comprise the most common injury type (>50%) in electric power workers and account for nearly 44% of medical costs *

• Work-related Musculo-Skeletal Disorders (WMSDs)
  ▪ Catch all term for group of painful disorders of muscles, tendons, and nerves.
    ▪ Specifically related to stress-related injuries caused from performance of job tasks
    ▪ Carpal tunnel syndrome, tendonitis, Chronic lower back pain, and tension neck syndrome are examples
  ▪ Can be acute injuries or chronic manifestation

• Cumulative Stress – by other names
  ▪ Repetitive Strain injuries
  ▪ Repetitive motion injuries
  ▪ Cumulative trauma disorders
  ▪ Overuse syndrome
  ▪ Soft tissue disorders

WMSD Risk Factors

- Risk Factor is a workplace condition associated with onset of a health problem
- WMSD risk factors are not just about repetition
  - Other factors such as vibration, posture, inconsistent force applications, etc. contribute to risk
- Effective Strategy to prevent and eliminate risks can involve:
  - Comprehensive ergonomic program
  - Work planning
  - Training
  - Health Monitoring

Where and how does Technology R&D play a role in characterizing or eliminating the risk?

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Areas of Research and Development Focus

- **Prevention**
  - Pre-task Baseline Conditioning

- **Diagnosis**
  - Field Assessment
  - Personal Feedback

- **Intervention**
  - On-the-spot treatment
  - Task realignment

- **Post-work Treatment**
  - Worksite therapy
  - Home therapy

• Addressing MSD-based injury in Workers
  - Stop acute incidents before they happen
  - **KEY:** Focus on disrupting accumulation of repetitive stress injuries

• Areas of focus
  - **Pre-work:** Preventing damage through conditioning/strengthening
  - **On-the-job:**
    - Diagnosis/self-monitoring in the field
    - Real-time Intervention
  - **Post-work:** Therapy at the worksite or at home to relieve stress and pain

• **NONINVASIVE DIAGNOSTICS FIRST!**
Assessing the State of the Injury

• Assessing muscle health
  - Biopsy (too invasive)
  - Imaging ($$$)
  - Pain scale (subjective)
  - Performance and Fatigue characteristics (max contraction levels over baseline)

• Establish robust diagnostics
  - Efficient
  - Noninvasive
  - Relatively inexpensive
  - Adaptive and Portable to Work site or Field
  - Consistent
  - Customized Profile

How can we noninvasively monitor health and prevention measures in workers at risk for developing WMSDs?
Neuromuscular Stimulation: Safe and Effective

- **Neuromuscular Electrical Stimulation (NMES)**
- **Elicitation of muscle contraction using electric impulses**
  - Potential to serve as a strength training tool for healthy subjects and athletes
  - Rehabilitation and preventive tool for partially or totally immobilized patients
  - Testing tool for evaluating the neural and/or muscular function *in vivo*
  - Post-exercise recovery tool for athletes
- **Main types of NMES (noninvasive)**
  - Transcutaneous Electrical Nerve Stimulation (TENS)
  - Faradic
  - Galvanic
  - Other noninvasive treatment is Ultrasound
Current NMES and US Characteristics

• **TENS**
  - An electronic device that applies electrical stimulation to the skin surface at the pain (or testing) site

• **Faradic versus Galvanic**
  - Faradic is higher frequency current (50-100Hz), whereas galvanic is low frequency
  - Faradic is shorter duration ranging from 0.01 to 1ms, galvanic is of long duration
  - Faradic is used to stimulate innervated muscles, and galvanic to denervated muscles

• **Ultrasound**
  - Emits sound waves (1-3 MHz) to create vibrations that help increase blood flow for relief of spasms
Current NMES Technology Characteristics

- **Advantages**
  - Portable Technology!
  - Effects well-understood
  - Can help establish some sort of baseline response
  - Can help with circulatory issues

- **Some Disadvantages**
  - Does not bypass sensory nerve system – painful sensation and skin irritation (“pins and needles”)
    - Faradic give mild pricking type of sensation, where galvanic give stabbing type of sensation
  - Not localized enough
  - Not eliciting deep tissue conditioning and re-education
  - Body adapts quickly and efficacy is decreased

**IS THERE AN ALTERNATIVE SINGLE TECHNOLOGY THAT CAN BE USED FOR DIAGNOSTICS, CONDITIONING, TREATMENT AND RE-EDUCATION?**

**YES, SIGMA Q**
Sigma Q Technology

- Sigma Q technology utilizes micro-gating to achieve muscular contraction and motor neuron nerve activation via topically applied electrodes/sensors, in a way which effectively bypasses the sensory nervous system.
- The technology is a patented combination of electrical charges and ultrasound called “charged packets”
- These “charged packets” use electrical energy in a way that penetrates muscle groups more deeply; the signal then continues along the nerve path within the body allowing for identification of related areas of inflammation and muscle weakness
## Comparative Features of NMES and Sigma Q

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<th>Sigma Q®</th>
<th>Galvanic</th>
<th>Ultrasound</th>
<th>Faradism</th>
<th>TENS</th>
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The product collection is designed to promote more immediate deep muscle healing by “re-activating” localized (micro-level) muscle tissue vs. merely treating the whole muscle (macro-level) area.

The treatment is also safely administered in water, so can be embedded in a spa system.

Treatments using Sigma Q technology have been successfully applied in the following areas:

- Diagnosis and assessment
- Nerve regeneration and neuromuscular re-activation
- Sports medicine
- Complementary medicine (analgesia and rehabilitation)

https://www.youtube.com/watch?v=zGOM9IbBUj8
Potential Technology Applications

**Prevention**
- Pre-task Baseline
- Conditioning

**Diagnosis**
- Field Assessment
- Personal Feedback

**Intervention**
- On-the-spot treatment
- Task realignment

**Post-work Treatment**
- Worksite therapy
- Home therapy

**Establish Baseline**
- Medical testing
- Conditioning
- Resistance Exercise

**Monitoring**
- Wearable Devices*
- Real-time
- Field Application

**Post-work treatment**
- Worksite spa therapy
- Home spa therapy

*Hexoskin example
Addressing OHS Research Gaps

• **Objective metric for improved conditioning and muscle recovery**
  - Potential for muscle fatigue recovery metric application (currently being developed for athletes)
  - Biosysco collaboration with Pepperdine University Department of Sports Medicine to help test the prototype application with Sigma Q™

• **Metric for Cumulative Trauma assessment**
  - Based on a proposed Fatigue-failure approach
  - Lower Back Cumulative Trauma Index
  - Biosysco collaborative efforts underway with Auburn University Department of Industrial and Systems Engineering and Human Factors/Ergonomics Studies
Other R&D Ideas on the Horizon

• Technology Upgrades
  ▪ Sigma Q Wearable Technology system design
    o Remote application of stimulation protocols (wireless)
    o Compatible with PPE and stressful work environments
    o Closed loop system with customized controls for worker
  ▪ Spa therapy unit for worksite (if updates needed)

• Further research
  ▪ *In vivo* fluid shift and muscle blood flow changes (fatigue-recovery impacts) with applied Sigma Q Technology
  ▪ Muscle loading and isometric strength testing with applied Sigma Q technology

Biosysco partners with Industry and academia to conduct short studies that support worker risk mitigation of MSDs
Summary and Key Takeaways

• The musculo-skeletal system depends on healthy performance of the neuromuscular junction and nervous system feedback loop
  ▪ Current non-invasive diagnostics and treatment technology involves stimulation of the muscle with electrical signals - neuromuscular stimulation (NMES) or Ultrasound application
  ▪ Widely used and noninvasive NMES devices/technologies include TENS, Galvanic (long duration, voltage dc) and Faradic (short duration, higher frequency current)
  ▪ These technologies, while portable, have several limitations for longer term use in cumulative trauma situations

• Work-related Musculo-skeletal disorders (WMSDs) are the leading type of injury in electric utility workers and account for a significant cost-impact to the industry
  ▪ Repetitive stress-based activity and environmental/clinical issues are part of the complex array of risk factors
  ▪ These injury risks need to be addressed and minimized or eliminated through effective ergonomics programs
  ▪ Incorporating new and advanced mitigation technologies can enhance worker safety and health, corporate costs, and operational performance
Summary and Key Takeaways

• **OHS Technology Research can be further developed in these areas:**
  - Prevention measures through pre-work conditioning and strengthening
  - Diagnosing/monitoring areas of weakness through wearable, remote technology
  - Active intervention to apply real-time treatment or appropriate task realignment measures
  - Post-work short therapy session at the worksite or at home

• **The Sigma Q™ system provides noninvasive muscle re-education, deep conditioning, diagnosis, and rehabilitation**
  - Patented technology uses waveform packets (pulsed pattern) of electrical activation combined with ultrasound to achieve full muscle contraction along the neural pathway, as well as circulatory release
  - The technology can be used in dry form with embeddable electrodes in wearable formats as well in wet form with spa and shower formats

• **Biosysco will continue to grow and expand partnerships with academia and industry to design/develop new technology applications**
  - Research focused on objective metrics to determine improvements in conditioning, performance, and decreased risk of WSMD injury
Next Steps

Biosysco would like to expand current partnerships with the electric utility S&H teams to conduct investigations and develop devices that support worker risk mitigation of MSDs.

QUESTIONS?

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