Introduction

In agriculture, musculoskeletal injuries pose the most common safety risk for workers and interfere persistently with the business economics. AgSafe estimated that approximately 40% of the reported sprains and strains injuries involve the back [1]. Because agriculture relies heavily on manual labor, the economic health of agriculture industry depends greatly upon the health of its workforce. Understanding the underlying biochemical mechanisms of injury and healing provides an interest in, biochemistry to improve worker safety and to promote efficacious healing therapies.

Animal Models
Animal models were established to induce an acute Medial Collateral Ligament (MCL) injury with a transection and then with a sustained submaximal static load simulating stooped posture. Two transection interventions were used: A Nonsteroidal AntiInflammatory Drug (NSAID) and a Platelet Rich Fibrin (PRF). Biomechanics, biochemistry, and functional recovery were assessed.

Evaluation Methods

Table 1: Injured Ligament Total Histology Index

<table>
<thead>
<tr>
<th>Region</th>
<th>Collagen</th>
<th>Elastin</th>
<th>Vascular</th>
<th>Total Histology Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0-3)</td>
<td>(0-3)</td>
<td>(0-3)</td>
<td>(0-3)</td>
<td>(0-6)</td>
</tr>
<tr>
<td>1</td>
<td>1.75</td>
<td>2.00</td>
<td>2.00</td>
<td>5.75</td>
</tr>
<tr>
<td>2</td>
<td>1.32</td>
<td>2.00</td>
<td>2.00</td>
<td>5.35</td>
</tr>
<tr>
<td>3</td>
<td>1.02</td>
<td>1.00</td>
<td>1.00</td>
<td>3.02</td>
</tr>
<tr>
<td>4</td>
<td>0.75</td>
<td>0.50</td>
<td>0.50</td>
<td>1.75</td>
</tr>
</tbody>
</table>

Table 2: Sham Ligament Total Histology Index

<table>
<thead>
<tr>
<th>Region</th>
<th>Collagen</th>
<th>Elastin</th>
<th>Vascular</th>
<th>Total Histology Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0-3)</td>
<td>(0-3)</td>
<td>(0-3)</td>
<td>(0-3)</td>
<td>(0-6)</td>
</tr>
<tr>
<td>5</td>
<td>0.75</td>
<td>0.40</td>
<td>0.40</td>
<td>1.59</td>
</tr>
<tr>
<td>6</td>
<td>0.45</td>
<td>0.50</td>
<td>0.50</td>
<td>1.45</td>
</tr>
<tr>
<td>7</td>
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<td>0.15</td>
<td>0.15</td>
<td>0.45</td>
</tr>
<tr>
<td>8</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>1.50</td>
</tr>
<tr>
<td>9</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>3.00</td>
</tr>
</tbody>
</table>

Material Properties: Material testing measured the mechanical performance of the Femur–MCL–Tibia segments with a force and displacement resolutions of 0.01 N and 0.001 mm, respectively. The segments were pulled to tensile failure at a strain rate of 10%/s (0.6-0.8 mm/s) [5]. Four parameters were assessed: load to failure, displacement, stiffness, and energy to failure 6.

Biochemical and Physiological Dynamics in Ligament Injury & Healing

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Purpose

The aims of this study are to 1) develop an animal model 2) characterize the biochemical response to ligament injury and healing 3) establish a ligament transaction injury healing protocol 4) improve the ligament injury and 5) investigate the efficacy of traditional treatment methods. The mild injury model will mirror the common injury experienced by workers, who are constantly stooped while performing agricultural tasks such as harvesting strawberries and hand weeding.

Economic Incentives

Substantial financial losses are associated with work related musculoskeletal disorders (WMSDs). The annual cost of Low Back Disorders (LBDs) exceeds $100 billion. In the US alone, 13 million people will develop LBDs annually due to their occupation making it the most prevalent musculoskeletal problem in the workplace [2]. Therefore, addressing the musculoskeletal disorders in agriculture will not only improve worker health and well being, but will also increase productivity, lower cost, and preserve a solid agricultural industry.

Stooped Work Posture

Stooped Posture is seen in many agricultural tasks when workers are bent forward and down at the waist and/or midback while maintaining straight legs. Sustained stoop exerts spinal ligaments and vertebral disks to high forces that may induce injury.

Animal Models

Animal models were established to induce an acute Medial Collateral Ligament (MCL) injury with a transection and then with a sustained submaximal static load simulating stooped posture. Two transection interventions were used: A Nonsteroidal AntiInflammatory Drug (NSAID) and a Platelet Rich Fibrin (PRF). Biomechanics, biochemistry, and functional recovery were assessed.

Initial Results

ELISA: VEGF ELISA results showed that on Day 5 the PRF treated animals that received no treatment had a significant increase in VEGF expression in comparison to sham controls (27.1 and 8.8 pg/ml). In the PRF treated animals VEGF expression increased two folds (1.9 and 9.7 pg/ml). Meloxicam (MX) treated animals showed no significant difference (10.9 and 13.8 pg/ml).

Histology: Initial findings show that collagen, cell organization, and vascularity scores (summarized as the total histology index) were higher in healing ligament (21.47) than in sham control (3.25) at all regions of analysis (Tables 1 and 2). Outer regions (skin and joint sides) appeared to show higher combined total histology index (12.3) than the same regions in sham controls (0.63).

Progress and Next Steps

• Animal models have been established.
• Treatment methods and experiments for ELISA, histology, and gait analysis have been piloted and optimized.
• Initial results show the utility of optimized laboratory methods in evaluating ligament injury.
• Future experiments will focus on: 1) scaling the study to evaluate statistical significance and 2) building and evaluating the mechanical testing apparatus. Submaximal injury will be further optimized and experiments will be repeated under submaximal injury with sustained static loading conditions to mimic occupational exposures under stooped posture conditions.

Experimental Design

Planned experiments and assessment timepoints

Summary

• ELISA has mapped the change in biochemical factors that respond very differently with melasocim or PRF intervention.
• Histology has characterized the course of injury and healing.
• Immediately after injury, Gait analysis (ITS) can track the recovery. Meloxicam seems to mask the pain and may not help healing. PRF treatment may actually help in healing.
• The initial studies with acute MCL transaction has set the basis for experiments to characterize injury response to sustained submaximal ligament injury.
• Findings from this study will help improve treatment protocols, reduce stooped work posture exposures to injury, and provide insights to effective injury prevention policies.

Literature Cited


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