



V1.0

Elbow Torque Tracker - Early Feasibility Technical Report

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Table of Contents

A. Abstract.....	3
B. Project Scope.....	4
1. Physical Biomechanical System.....	4
2. Device Scope.....	5
3. Use Cases.....	5
C. Market Segment.....	6
1. Users.....	6
2. Competitive Matrix.....	6
3. IP Search.....	6
4. Early User Feedback.....	6
D. Testing Systems.....	6
1. Testing Questions.....	6
2. Verification Testing for Sensors (Benchtop-Oriented).....	7
3. Verification Testing for Testing Together (Benchtop-Oriented).....	7
4. IRB Testing Expectations.....	8
E. Mechanisms.....	9
1. Components.....	9
2. Block Diagram/ Flow Chart.....	10
3. Proprietary Algorithm.....	11
4. Basic BOM.....	11
F. Related Documents.....	11
1. Customer Questions.....	11
2. Email Template.....	12
3. Predicate/ Background Research (Expanded).....	13

A. Abstract

Injury to the UCL was first described in javelin throwers in 1946 [1]. UCL injuries are common in overhead throwing athletes, leading to elbow instability, pain, and loss of control and stamina [2]. This ligament is under significant strain during high velocity pitching, most notably between 20 and 120 degrees of flexion [3] during the late cocking and early acceleration phases of throwing [4–6]. During overhead throwing, a large valgus force on the elbow created by humeral torque is countered by rapid elbow extension, creating significant tensile stress along the medial compartment, shear stress in the posterior compartment, and compressive stress in the lateral compartment. External rotation of the shoulder through the late cocking phase results in significant elbow strain, and the effect of repetitive throwing is ligament failure. Despite attempts at injury prevention, UCL injury rates continue to climb in throwers of all levels.

The Elbow Torque Tracker device targets muscle groups and creates time-dependent models for arm-throwing motions to provide a real-time estimate of elastic stress of the UCL. The device consists of passive, electromechanical sensors that non-invasively fix on the elbow region of a user's dominant arm, and continuously streams muscle firing and positional information from a local CPU to a secondary UI downloaded through a mobile application. The UCL provides both technical and non-technical indicators for high elbow torque (and other stresses associated), such as color indicators for at-risk motions and in-depth description of individual data points.

Early surveys of customer stakeholders (clinical staff, college-level athletes, etc.) demonstrate an underdeveloped market for providing proper clinical tools for managing UCL-based physical therapy. There are three clear needs: a non-invasive management for system tracking UCL condition outside clinical settings (i.e. ultrasound imaging); an unobstructive method for contextualizing overhead throwing techniques in the field (i.e. without IR technology); an accurate and scientific estimation for clinical staff to understand professional athletes conditions. Driveline's Pulse, the primary competitor in this market, demonstrates clear gaps in these market needs, especially as a scientific approach towards UCL stress estimation.

Cornell DEBUT Phase B's goals for the 2025-2026 year consists of the following:

1. Survey more stakeholders in the clinical and professional athletics settings for feedback on the biomechanical system, competitors devices, risks, and user needs for the product
2. Creating a Minimum Viable Product (MVP) for the device that meets basic verification/characterization testing requirements
3. Conduct an IRB-approved clinical study to validate viability for potential investors and future regulators
4. Identify national regulatory requirements (FDA) related to the Elbow Torque Tracker, and create a traceable design to ensure quality control and assurance

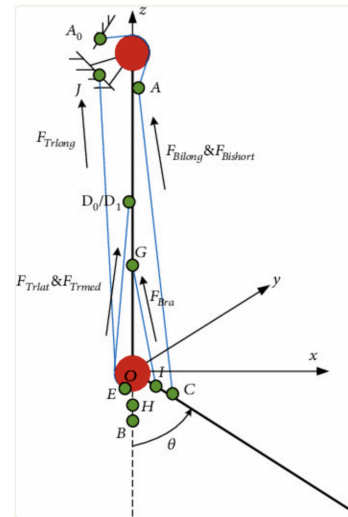
B. Project Scope

1. Physical Biomechanical System - *What is the basic principle for the device's operation? What is the plan for integration?*

The elbow physical model is the basis of elbow muscle torque prediction. The elbow physiological model established [7] includes three parts: Hill musculotendon model, elbow musculoskeletal model, and elbow joint kinematic and moment model.

The major scientific basis for the synthesis of these three models originates from a prominent applied biomechanical article from Hu et. al (“An Improved EMG-Driven Neuromusculoskeletal Model for Elbow Joint Muscle Torque Estimation”). The article recommends methods for estimating ligament stress/strain with elbow torque through the various muscle models including

1. Hill Muscle Model for Muscle Force Estimation
2. Positional Data on the Bicep Brachii, Tricep Brachii, and Brachialis
3. Elbow Torque as the Sum of Primary Muscle Group Torque Arms and Muscle Force Estimation



$$\tau_{\text{human-el}}(\theta, t) = \sum_{i=1}^m (r_i(\theta) \cdot F_M^i(\theta, t)).$$

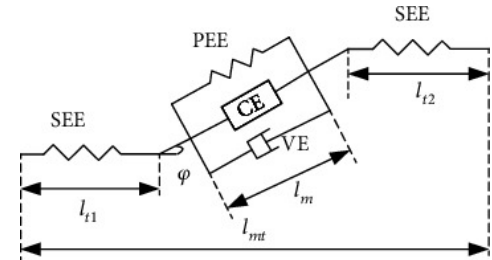


Figure 1 (Top), 2 (Left), 3 (Right): Integrated Model for Understanding Design Inputs for Hill and Elbow Musculoskeletal Model; Final Model for Summated Torque Scalar on the Elbow Joint; Hill’s biomechanical schematic for interpreting individual components of muscle firing

The Hill musculotendon model is used to calculate the force of muscle contraction according to muscle activation. The elbow musculoskeletal model consists of an amalgamation of muscle architecture and bone structure of the elbow joint. The elbow joint kinematic and moment model is used to determine the force arm of the elbow flexor and extensor groups acting on the rotation axis of the elbow joint during movement and finally solve the muscle resultant moment. This is a schematic of the improved musculoskeletal model.

2. Device Scope - *What is an overview of components, inputs, and outputs of the design? How will the data be used for analysis*

Device Inputs	Device Outputs	Impacts with Data
1. mV (From Muscle Stimulation) 2. ϕ, Θ, Ψ (From Arm Orientation)	1. Visualization of Torque on UCL over time <ol style="list-style-type: none"> Visual green below safe cutoff Visual yellow/red zones 2. Maximum Torques relative to orientation 3. Maximum Values (Count, Torque, and Bend)	1. Longitudinal study (Shift of fatigue curve after training regimen) 2. Effect of different pitch types on elbow fatigue 3. Effect of proportional muscle stabilization of the joint
Data Usage		
1. Used to analyze athlete health <ol style="list-style-type: none"> If a prospective player is exceeding the failure threshold continuously, they are at a high risk to get hurt and be unable to play. They would be an ineffective draft choice and a team might choose to select another player. 2. Used to prevent athlete injury <ol style="list-style-type: none"> If failure fatigue region is quantitatively assessed and developed, coaches, managers, and high performance teams would be able to structure athlete training and playing around this limit If it is shown that different pitch grips result in different levels of joint stress, when players enter high risk fatigue zones, managers would be advised to not have athletes throw this pitch for risk of ligament failure. 3. Used to prevent reinjury and optimize recovery <ol style="list-style-type: none"> Structured return to play with a controlled plan to reach performance pre-injury, without exceeding failure bounds on the weakened ligament while it is restructuring Using EMG data to track muscle atrophy and increased strength through training 4. Used to optimize player performance <ol style="list-style-type: none"> Safely approaching higher velocities and pitch break values through tracking muscle firing and stabilization while remaining in healthy ranges of torque. 		

3. Use Cases - *How are individuals intended to interact with the product? What is a step-by-step process of the workflow? (When do they need it, what are limitations, etc.)*

A. Purchase through Website (Direct-to-Consumer Model)

- Normal Model Includes Electronics, Sensors, Access to Software, Protocols, and a set of Sticky Pads (for 5 uses) in a single shipped box
 - Electronics - Usable
 - Stick Pads - Single use

- Accessible without a prescription for all types of patients and non-quoted (fixed rate)
- B. Assembly
- Patient cleans the Arm with an alcohol wipe, potential need for clean shaven arm
 - With the protocol provided, identify the specific muscle groups and attach the sticky pads to the specific groups for the sEMGs and the IMUs
 - Connect the individual sensors to the sticky pads, and provide power to the individual components (either coin cells or a central power source from the arm compression sleeve)
 - Access the online software through a special log-in system to the patient (will store NO data, but will pay to be granted access to post-process the data from the arm brace)
 - Calibrate the sensors with a premade procedure (Either shown in the software or through the physical paper protocol)
- C. Usage
- Wireless connection of the sensors to the software (monitoring continuously or non-continuously)
 - Physical button to start recording data specifically
 - Conduct an initial risk analysis to determine issues with device during usage
 - Individuals pitch with “investigative purpose” during pitching sessions as opposed to during all practices, real-world usage, etc.
 - Use during practices but not every practice, ideally once in a while to monitor the patient’s condition over time
- D. Completion
- Physical button to stop recording data, power off the device
 - Save data on the software as a .csv, speciality figure data file, etc.
 - Remove the sticky sensors, throw out the sticky pads, disinfect and save the sensors

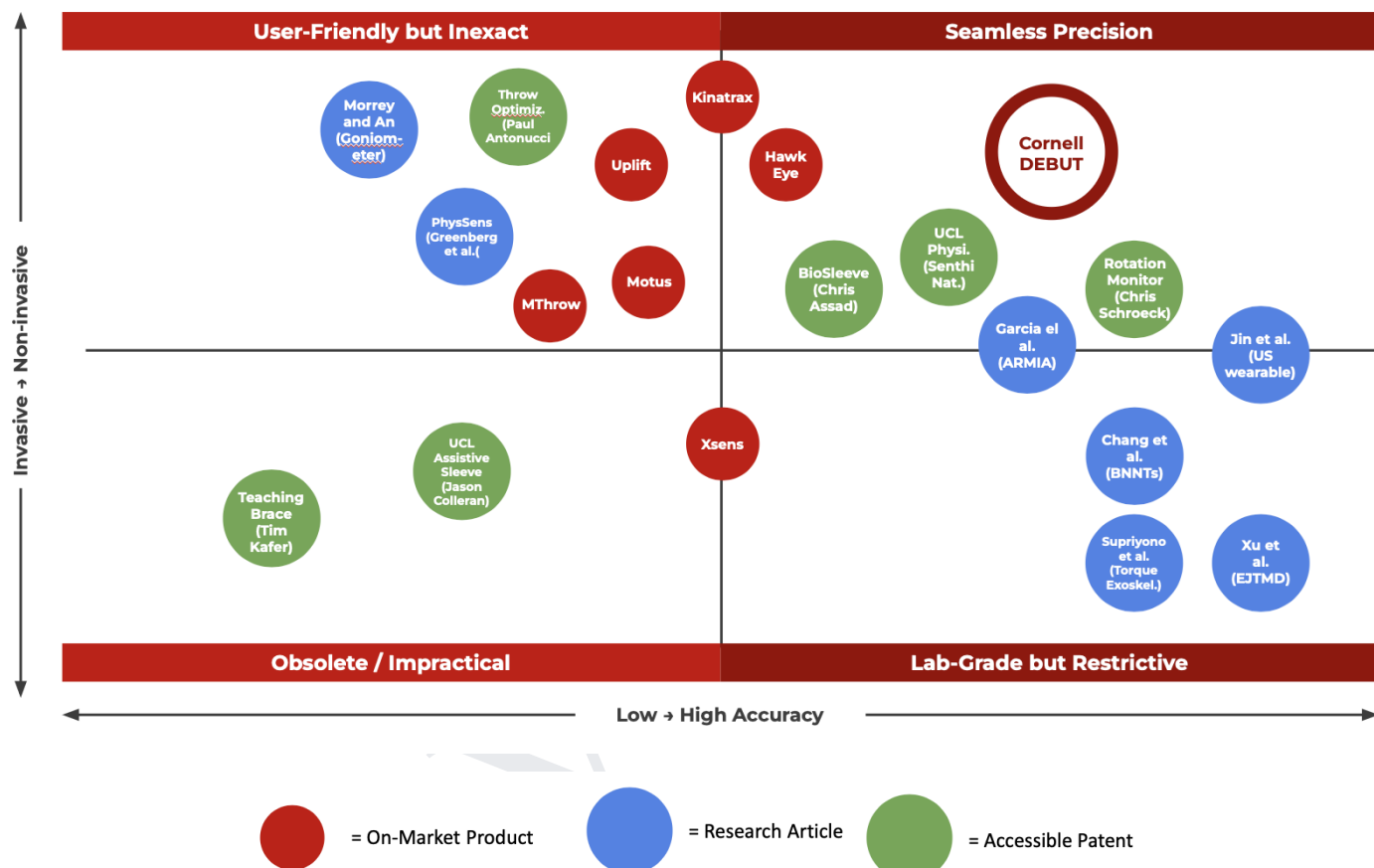
C. Market Segment

1. Users - *Who are the SPECIFIC users in that will be consulted directly through further development?*

Our targeted customer segment includes high-intensity professional athletes, especially in arm throwing sports such as baseball, cricket, tennis, etc. As a form of direct-to-consumer product, clinical staff members focused on physical therapy or upper-arm management have access to the technology and software for data processing. With the potential for MATLAB as a modelling tool for illustrating 3D motions in conjunction with torque forces in a downloaded-application, there is a potential for subscription models in order to pay for individual overhead costs for the compiler softwares. Additionally segments include other normal customers post-UCL surgery managing conditions with physical therapists. Beyond this core market segment, the goal for the device is to be as patient-compatible as possible to be translated across other sports fields for individuals in all levels of athletic levels.

2. Competitive Matrix - *What are the major competitors within this market? What differentiates a product such as this?*

Competitive Matrix Accuracy vs Invasiveness



3. IP Search - *What are current products on market? What does their IP look like?*

US Patent Number	Name	Filing Date	Exp. Date	Description
US20170312576A	Senthil Natarajan	2017-04-01	2017-11-02 (Abandoned, No similar patent pursued)	Wearable Physiological Sensor System for Training and Therapeutic Purposes
US9278453B2	Christopher Asaad	2013-05-28	2033-08-30 (Non-provisional filed)	Biosleeve Human-Machine Interface

US9299248B2	Stephen Lake	2014-01-21	2034-04-09 (Non-provisional filed)	Method and apparatus for analyzing capacitive EMG and IMU sensor signals for gesture control
US11571146B2	Christopher A. Schroeck	2019-07-03	2041-01-01 (Non-provisional filed)	Rotation Monitoring System and Method
US20250186234A1	Jason Colleran	2024-12-11	2025-06-12 (Publication, Pending)	Arm Sleeve that Provides Assistance during an Arm motion
US 10,314,536 B2	Ben Hansen	2017-10-26	2025-03-17 (Non-provisional filed)	Pulse Driveline Patent
US8981904B2	Hendrik Johannes Luinge	2012-03-27	2032-07-09 (Non-provisional filed)	Compression of IMU data for transmission of AP (Xsens)

4. Early User Feedback - *What is feedback from clinicians surveyed thus far? Additionally, what does further market research reveal?*

Jamie has conducted user interviews with Gus Magill and Carson Mayfield, both on the Cornell Baseball Team. See Jamie's full notes breakdown [here](#). Gus tore his UCL, but instead of full Tommy John Surgery (UCL reconstruction), he had a less invasive procedure where a synthetic ligament was placed instead of harvesting a tendon from another part of the body. His recovery process focused on gradual strengthening and working up to full intensity pitches. He liked the concept of the device; however, he kept referencing [Driveline's Pulse](#), a forearm-worn tracker used by many pro and college teams to track the workload and torque on the elbow. This device seems less detailed than ours, just outputting how hard the pitcher throws. He prefers a design that is minimal (sleeve or small, strapped on sensors). Carson did not have a UCL tear but was born without part of his shoulder labrum, causing unique shoulder issues. He believes a full brace would be too restrictive for pitching. As long as it is lightweight and non-intrusive, he has no other concerns.

D. Testing Systems

1. Testing Questions - *What are we looking to affirm from the start of testing?*
 - a. *Step 1: Establish our trackable variables-* What will we be able to measure with the sEMGs? Will we be able to track location? Speed? Generally kinematics and muscle firing activity is useful for integrating for a torque calculation, but do we need baseline MVICs for the user?

- b. *Step 2: Developing the model*- Utilizing the article and the openSim models. Once we know what we can track, augmenting the model in the paper to fit our parameters is necessary. This will require calculating muscle force and strength, using flexion angle, fiber length, and forward kinematics (reference the Hill model). Through step one, I would say use fixed variables with averages for the variable we intend to measure through the actual model. Just start by integrating trackable variables to an output.
 - c. *Step 3: Introduce the sEMGs* - Start working with some live tracking data.
 - d. *Step 4: Build the sleeve* - How individualized do we intend the device to be? Does it require a physician measuring points from the joint and applying? Do we intend to make it more universal? This will be key in order to test whether the device is functional at high speeds as the athlete is throwing.
2. Verification Testing for Sensors (Benchtop-Oriented) - *How will individual systems be verified prior to IRB testing?*
 - a. sEMGs - Stimulate with a Power Supply to induce specified voltages and ensure downstream transduction in the CPU. Following preliminary testing, place on a bicep and conduct attributable muscle contractions that affirm the correct voltage reading is collected
 - b. IMUs - Create a basic protractor based benchtop that set's the IMUs to specific orientations to affirm correct downstream transduction of orientation. Following this, place on the bicep and affirm intended bicep angle correlates with received bicep angle
 3. Verification Testing for Testing Together (Benchtop-Oriented) - *How will the sensors be tested together prior to IRB testing?*
 - a. IMUs/sEMGs - Create an arm-like structure that holds the sensors integrated into the v1.0 prototype and provides degrees of freedom about an elbow joint. Add components that stimulate the sensors continuously.
 - b. The dark gray boxes represent sEMG placement. Figure 5 showcases muscles #1-3 that we intend to target (the biceps brachii long head, biceps brachii short head, and brachialis). Figure 6 showcases muscles #4-6 that we intend to target (the triceps brachii medial, lateral, and long head).

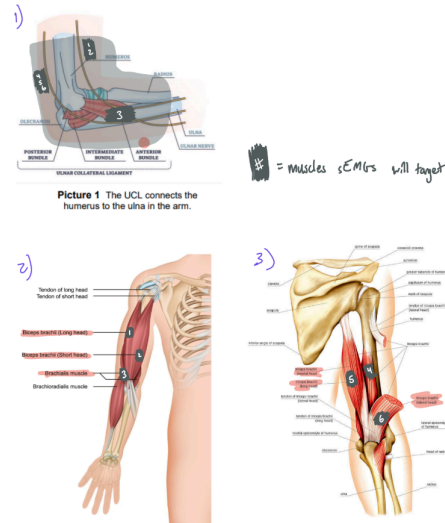


Figure 4 (Top), 5 (Left), 6 (Right): The relative placement of the device; the major muscle groups on the arm; additional diagram of arm muscle groups

4. IRB Testing Expectations - How will we ensure testing meets the expectations to operate as a fully functional diagnosis to the IRB comparative metrics?

****Comparison of general elbow torque, not strain**

	Standard Use Cases (Motion Capture)	Cornell DEBUT Elbow Torque Tracker (Exp.)
General	Set-up a general-use virtual reality camera or speciality IR room to track arm positional information with the MATLAB inverse dynamics library to compute elbow dynamics	Set up the sensors on the individuals arm and connect to the online application, and with the pre-discussed Hills-Muskoskeletal model, estimate elbow torque
Tools	<ol style="list-style-type: none"> 1. High-Definition Camera with Stand 2. Reference Point (Contextualizing Scaling Factor) (i.e. Height, Weight, Forearm Sizing) 	<ol style="list-style-type: none"> 1. sEMGs and IMUs with Connection Brace
Workflow	<ol style="list-style-type: none"> 1. All players will register, request medical background/ history with UCL injuries, be given informed consent, etc. 2. Randomly assign each player to start with/without the therapy brace 3. Administer Brace Therapy <ul style="list-style-type: none"> ● Clean arm and Apply Sensors with Brace ● Connect with the Online Application ● Have the Player Pitch a Variety of Pitches (Varying Speed, Type, and Exit Angle) 4. Administer No Brace Therapy <ul style="list-style-type: none"> ● Record Weight and Height 	

	<ul style="list-style-type: none"> ● Calibrate the Camera with Reference Point ● Have the Player Pitch a Variety of Pitches (Varying Speed, Type, and Exit Angle) <p>5. Testimonies for Usability and Invasiveness</p>
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E. Mechanisms

1. Components - *What are the major components of the device?*

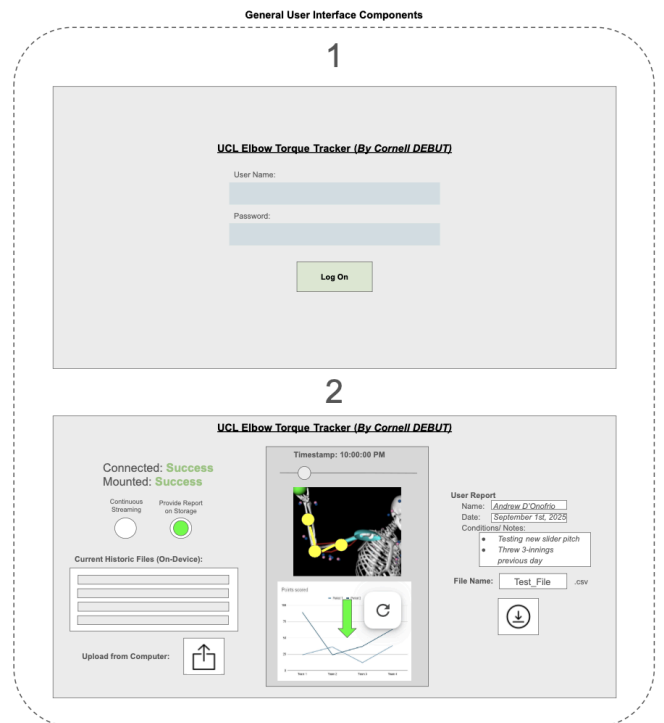
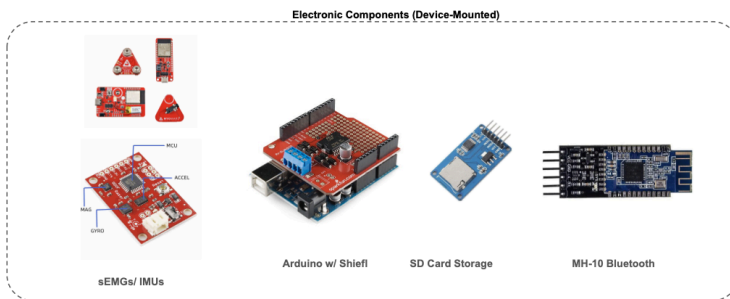
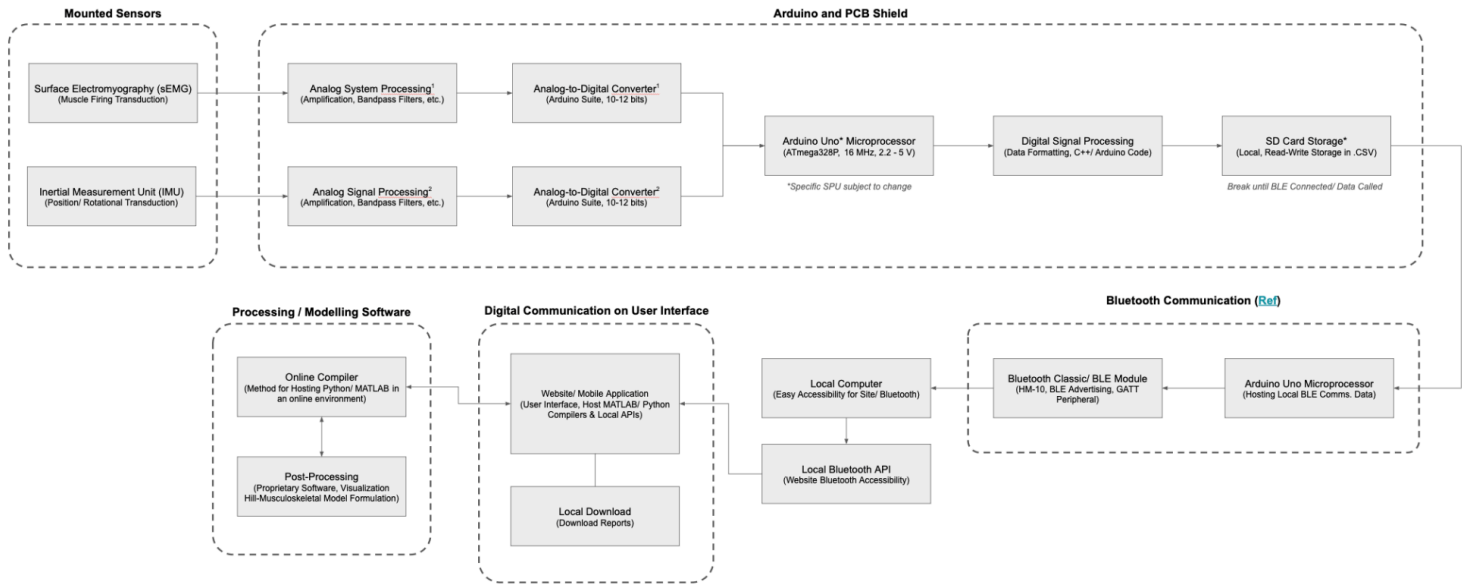
The Elbow Torque Tracker device targets muscle groups and creates time-dependent models for arm-throwing motions to provide a real-time estimate of elastic stress of the UCL. The device consists of a passive, electromechanical brace that non-invasively fixes on the elbow region of a user's dominant arm, and continuously streams muscle firing and positional information from a local CPU to a secondary UI downloaded through a mobile application. The UCL provides both technical and non-technical indicators for high elbow torque (and other stresses associated), such as color indicators for at-risk motions and in-depth description of individual data points.

For the sensors, the major components consist of two parts. Surface electromyography (sEMG) sensors and inertial measurement unit (IMU) sensors. sEMG provides muscle contraction force through a voltage reading from the surface of the skin as a function of time that, with a correlation curve, converts into estimated local contraction force. IMUs provide gyroscopic orientation as a function of time, more specifically the 3D angle scalars of rotation (pitch, roll, and yaw).

Sensors are processed through an analog processing system encompassed through a design PCB for optimizing signals for an Arduino Uno/Duo processing. After the signal transduction is completed. Received, and stored through the analog-to-digital converter, specialized Arduino BLE bluetooth modules send data to a local computer for further post-processing on the specialized UI. The UI will consist of the proprietary scripts that convert the voltage and positional raw data into usable elbow torque data (with post-processing scripts executed via Python/MATLAB triggered through the UI). Additionally, data visualization methods will be implemented in order to graph stresses on the elbow over-time in addition to 3D models of the arm throwing motions with respect to force.

2. Block Diagram/ Flow Chart - Provide a visual aid for the devices components

UCL Elbow Torque Tracker



See the following diagram - [Link](#)

3. Proprietary Algorithm - *What is the anticipated model for synthesizing data points in order to estimate outputs?*

The intended system is meant to correctly calculate elbow varus torque in connection with UCL failure prediction and mediation. By finding quantitative markers of ligament strain, these figures can be compared to failure bounds, determining individualized reports of the effects of fatigue, biomechanics, and muscle firing on injury. This will enable coaches, athletes, and high performance teams to make training choices with confidence that they are decreasing injury risk and optimizing performance.

[An Improved EMG-Driven Neuromusculoskeletal Model for Elbow Joint Muscle Torque Estimation](#): Due to the complexity of human structure and muscle coordination in the process of movement, it is difficult to measure the torque of human joints in vivo directly. In the past, elbows have been modeled by a two-muscle model. The number of muscles in the improved model is more complete, and the geometric model is more in line with the physiological structure of the elbow. The simulation results show that the prediction results of the model are more accurate than those of the traditional double-muscle model. Compared with the elbow muscle torque simulated by OpenSim software, the Pearson correlation coefficient of the two shows a very strong correlation. One-way analysis of variance (ANOVA) showed no significant difference, indicating that the improved elbow neuromusculoskeletal model established in this paper can well predict elbow muscle torque.

4. Basic BOM - *What are the primary components/vendors of the device?*

BOM for Device Itself:		
Item	Quantity	Unit Price
sEMGs - only option that does not break the bank. Gather muscle contraction data to feed into the Hill Equation.	6	43.50
Brace - might need a bigger one in order to cover all six muscles.	1	9.99
IMUs - feed IMUs into OpenSim model (Arm26) to calculate the muscle velocity, moment arms, and muscle-tendon length	6	2.675

TOTAL COST: \$287.04

F. Related Documents

- Customer Questions
 - Have you ever experienced a serious UCL injury (sprain or tear)
 - How long was the recovery process? (Until throwing, Until full output)
 - Would you be interested in quantitative testing looking at ligament failure?
 - If you knew you were approaching an injury, would you restructure your training?
 - Would a device like this constrict your movement in any way?
 - How do you know when you are overexerting when throwing?

- If a device told you to stop throwing but you felt fine, would you listen to the device?
- What aspect of the throwing motion do you feel is the riskiest?
- What kinds of feedback do you receive from coaches or trainers?
- How does fatigue or pain in your arm vary throughout practice or a game?
- Can you describe the feeling of fatigue or pain caused by throwing/overexertion?
- Have you been taught any specific throwing mechanics to reduce injury risk?
- How do you track your own performance or improvement—do you use video, data, or just feel?
- What do you currently do to mitigate injury?
- How comfortable are you wearing braces or sleeves while playing?
- What's your tolerance for having wires, patches, or straps on your arm while playing?
- How often would you realistically check data or stats from a training session?
- What signs or symptoms do you look for before deciding to stop throwing?
- How do you mentally respond to pain or fatigue—do you push through or stop?
- Do you think a data-based tool could replace the judgment of a coach or trainer?
- What times of the season (e.g., preseason, postseason) are you most concerned about injury?

2. Email Template

Hi _____,

I hope this email finds you well. My name is _____, and I am a student at Cornell University who works on Cornell DEBUT, an engineering design team dedicated to creating medical devices.

Device description: We are interested in developing an elbow torque tracking device as a diagnostic tool for players and high performance teams to tailor workouts and game decisions to keep athletes safe and prevent injury. Potential research questions that would be aided by this device would be whether different pitch types result in a higher level of elbow strain and tracking the onset of fatigue as determined by pitch count. Integrating an EMG based model, high performance teams could see muscle firing rates around the bicep, tricep, and forearm, and track strength training outcomes with decreased elbow strain. Also, coaches could have better insight into when to pull players from the game based on decreased efficiency but also when they enter a 'high-risk' zone where ligament failure is imminent.

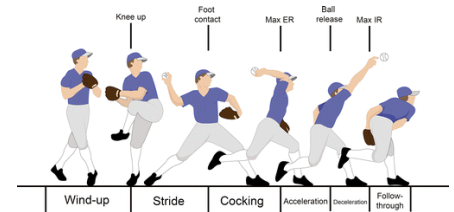
If you are interested, we would like to gather your thoughts and insight regarding the market and need for this device. A 30 minute Zoom call would be much appreciated. We are flexible and happy to accommodate your schedule.

3. Predicate/ Background Research (Expanded)

Thrower's Elbow

Background: This article is to understand the biomechanics of throwing and the typical injury patterns is essential for clinicians to develop effective treatment plans.

Summary: It discusses common injuries in adult overhead throwers, focusing on the shoulder and elbow regions. It highlights the role of imaging in identifying these injuries and emphasizes the need for a comprehensive understanding of the underlying anatomy and biomechanics. The review also covers various imaging techniques and their applications in diagnosing specific injuries, aiding in the development of targeted treatment strategies



EMG-Driven Neuromusculoskeletal Model

Background: Due to the complexity of human structure and muscle coordination, directly measuring joint torque in vivo is challenging. This new model improves on traditional elbow models by including a more complete set of muscles and a geometry that better matches the elbow's physiological structure. Simulation results indicate that the new model provides more accurate torque predictions compared to the traditional model. The improved model shows a very strong correlation with OpenSim software simulations, and statistical analysis (ANOVA) reveals no significant differences, demonstrating the effectiveness of the model in predicting elbow muscle torque.

Summary:

The proposed model expands upon the traditional elbow double-muscle musculoskeletal model by incorporating a more comprehensive set of muscles and a geometric structure that closely aligns with the elbow's physiological anatomy. Simulation results demonstrate that this enhanced model offers more accurate torque predictions compared to the conventional model. The model's predictions exhibit a strong correlation with elbow muscle torque data simulated using OpenSim software. Statistical analysis indicates no significant differences, confirming the model's reliability in estimating elbow muscle torque.

Weakening and factors of baseball pitchers

Summary/background: This study examined the impact of repetitive pitching on the dynamic stabilizers of the elbow joint, specifically focusing on the ulnar collateral ligament (UCL) and forearm flexor-pronator muscles (FPMs). Pitching 100 balls reduces the dynamic stabilizing ability of the elbow, leading to increased laxity. To protect the elbow joint, pitchers should limit themselves to fewer than 100 pitches per game or rest after 100 pitches.

[Elbow Instability](#)

Background: The elbow is a complex joint stabilized by both bony and ligamentous structures. Key stabilizers include the ulnohumeral articulation, which is a hinge joint, and the radiocapitellar articulation, which allows for rotation. The medial collateral ligament (MCL), also known as the ulnar collateral ligament (UCL), plays a crucial role in resisting valgus stress, especially during activities like throwing.

Summary: The article discusses the elbow's osseous anatomy, including the distal humerus, proximal radius, and ulna, highlighting their roles in joint stability. It details the ligamentous stabilizers, focusing on the MCL complex, which consists of the anterior bundle, posterior bundle, and transverse ligament. Diagnostic maneuvers for valgus elbow instability are reviewed, such as the valgus stress test, milking maneuver, and moving valgus stress test. These tests assess the integrity of the MCL and help identify instability patterns. Imaging techniques like ultrasound and MRI are also discussed for confirming diagnoses and planning treatment.

[Muscles across elbow joint](#)

Background: The elbow joint's stability and functionality are heavily reliant on the coordinated activity of its surrounding muscles. Understanding the specific roles of these muscles during various movements is crucial for diagnosing and treating elbow pathologies, as well as for designing effective rehabilitation protocols. Electromyographic analysis allows for the precise measurement of muscle activation patterns.

Summary: This study uses EMG to analyze the muscle activity across the elbow joint during different movements. The findings highlight the differential activation patterns of muscles (biceps brachii, brachioradialis, triceps brachii, and forearm flexors and extensors) during specific elbow motions. These insights contribute to a deeper understanding of the elbow's dynamic stabilization and can inform clinical practices and rehabilitation strategies.

[Elbow joint torque estimation](#)

Background: Accurate measurement of elbow joint torque is crucial for understanding joint mechanics, diagnosing musculoskeletal disorders, and designing rehabilitation protocols. Traditional methods, such as isokinetic dynamometry, are often limited by their need for specialized equipment and controlled environments. Surface EMG offers a non-invasive alternative to assess muscle activity, while joint kinematics provide information about joint movement. Combining these data using machine learning techniques, like ANNs, can enhance the estimation of joint torque, offering a more accessible and dynamic approach to evaluating elbow function.

Summary: The study investigates the use of surface EMG and joint kinematics to estimate isokinetic elbow joint torques through artificial neural networks. By analyzing the relationship between muscle activation patterns and joint movement, the researchers developed a model capable of predicting elbow torque. This approach demonstrates the

potential of integrating EMG and kinematic data with machine learning techniques to provide accurate and real-time assessments of elbow joint function.

Elbow Braces on Baseball players

Background: The ulnar collateral ligament (UCL) plays a crucial role in resisting valgus stress. Elbow braces have been developed to protect the elbow joint, but their effectiveness in reducing medial elbow joint space gapping during repetitive throwing had not been thoroughly investigated prior to this study.

Summary: In a controlled laboratory study involving 25 high school baseball players, each participant pitched 100 times under two conditions: without an elbow brace (control) and with an elbow brace. The ulnohumeral joint space was measured ultrasonically before pitching and after every block of 20 pitches. Results indicated that, in the control condition, the ulnohumeral joint space increased significantly after 60 pitches. Conversely, in the elbow brace condition, the joint space remained relatively stable throughout the pitching session. Statistical analysis revealed that the ulnohumeral joint space in the control condition was significantly greater than that in the elbow brace condition after 60 pitches, suggesting that the brace effectively prevented joint space gapping associated with repetitive throwing.

Recommendations: Overall these articles have helped in the research of this device in that it should be designed for continuous tracking over time to monitor changes in muscle performance and elbow torque, helping with long-term rehabilitation or strength training goals. And that it's important to make sure we are taking into account: monitoring soft tissue health, integrating imaging data, and ensuring comfort/usability.: