DEFN-15-189

# PROJECT DEFINITION

**APPROVALS**

| ROLE | NAME | SIGNATURE | DATE |
|---|---|---|---|
| Team Leader | Wyatt Moscoso | | 11/21/2014 |
| Research Student | Tyler Jacobs | | 11/21/2014 |
| Research Student | Jordan Schmitz | | 11/21/2014 |
| Research Student | Sherilyn Bumatay | | 01/30/2015 |
| Advisor | Dr. David Reinkensmeyer | | 11/21/2014 |
| Advisor | Dr. Jim Hicks | | 11/21/2014 |

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| **Author:** | *Tyler Jacobs* |
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***Concussive Forces and Brain Trauma in Competitive Sports***

# Revision History

| REV | DESCRIPTION | DATE | APPROVED BY |
|---|---|---|---|
| - | Initial Release | 10/02/2014 | Tyler Jacobs |
| 002 | Revised definition | 11/21/2014 | Tyler Jacobs |
| 003 | Revised: project cost, risk mitigation, project milestones and team rolls and responsibilities. | 01/29/2015 | Tyler Jacobs |
| 004 | Added Sherilyn to the group. Revised resource estimation. | 01/30/2015 | Tyler Jacobs |
| 005 | Updated project objectives and project milestones | 05/15/2015 | Tyler Jacobs |
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# 1 PROJECT OVERVIEW

## 1.1 Executive Summary

Most sports have a certain degree of danger associated with them, due to flying objects and bodies colliding at high speeds. Soccer and water polo are particularly dangerous for one of the most important parts of the human body; the head. Head injury in these sports may stem from contact with the goal posts, other players, the side walls (in water polo) or the ground (in soccer). However, these sports bear a unique danger to the head when compared with other competitive sports due to the nature of ball interaction. Soccer is the only competitive sport that involves and condones purposeful head contact with the ball, while water polo is one of the only sports that involves ball flight almost exclusively in a plane parallel with head altitude. As a consequence of engaging in these sports, risk of head injury, especially concussions due to such ball interactions, is dramatically increased. In 2009 alone, hospitals reported 24,184 cases of soccer head injury, and 28,716 cases of water polo head injury (American Association of Neurological Surgeons – AANS). Furthermore, head trauma in these cases can cause a plethora of disabilities. These can range from loss of motor function to complete paralysis to death in the most severe cases.

The most common of these adverse consequences include the two aforementioned modes of damage. Traumatic Brain Injury, which is defined as a blow or jolt to the head that disrupts normal function to the brain. This is the main, recordable method of brain disruption (AANS). This sort of injury is classified with a set of values known as the GADD severity index, which measures the amount of acceleration of the head as a function of its exponent. This calculation yields a single value that represents the intensity of collision, acceleration, and therefore the danger of the impact. Even more disconcerting, however, is the presence of Chronic Traumatic Encephalopathy, which occurs due to repeated sub-concussive impacts to the head, and can have long lasting effects. This is equivalent to “creep,” in engineering terms, of damage over time to the brain. After many instances of sub-concussive impacts, which seem harmless as the time, damage slowly builds to a critical level. Repeated sub-concussive impacts build up to major concussive levels. These concussions can be much more severe even if the sub-concussive impacts never reached the magnitude of a singular concussive impact (Spiotta, Bartsch, and Benzel 2011). This is a concern for many athletes, as it is hard to gauge how far along the path of CTE one is. CTE’s are quite difficult to study in a limited time span, it will not be a focus of the experiment, although it is still a serious consideration.

The existence of these serious injuries make it critical to reduce the amount of risk taken when participating in these sports. Specifically, our team is searching for methods of minimizing the amount of impact force imparted to the head by ball contact. Interestingly, there is little to no precedent for tests on ball specifications and their implications on impact forces in these two sports.

# 2 PROJECT DETAIL

## 2.1 Project Objective(s)

Objective 1 – The primary goal of this research is to ascertain whether ball inflation pressure has a significant impact on traumatic brain injury (TBI) and chronic traumatic encephalopathy (CTE).

We shall conduct experiments using an Anthropomorphic Testing Dummy (ATD) outfitted with accelerometers to find the worst case scenario for concussions while varying ball pressure and velocity.

Objective 2 – Test existing water polo head gear currently in the market.

We shall compare the data of water polo ball impacts on an unprotected head to a protected head to determine whether the head gear makes a significant impact on protecting the water polo players head.

Objective 2 – Testing the accuracy of the G-Force head-strap accelerometers.

We shall compare the data obtained from the Anthropomorphic Testing Dummy (ATD) accelerometers to that of the G-Force trackers the soccer teams are wearing during practice.

## 2.2 Scope Details

Experimentation, data analysis, statistical analysis and publication.

## 2.3 Project Milestones

| Milestone Name | Target Date | Comments |
|---|---|---|
| Concussion research | 12/19/2014 | Research published literature on concussion research in soccer and water polo. |
| Pre experimentation | 01/23/2015 | Dry run experimentation with ball launcher and radar gun. |
| Experimentation | 02/12/2015 – 02/20/2015 | ATD has been ordered and has a projected arrival date of 02/12/2015. |
| Data analysis | 03/30/2015 – 04/13/2015 | Extract data from data acquisition system (DAS). |
| Statistical analysis | 04/27/2015 – 05/4/2015 | P-test, T-test in Matlab |
| Publication | In progress | |
| | | |

## 2.4 Project Team

| # | Name | Project Role | Email | Phone | Standing | Units |
|---|---|---|---|---|---|---|
| 1 | Wyatt Moscoso | Team Lead | wmoscoso@uci.edu | (909) 342-2669 | Senior | 2 |
| 2 | Tyler Jacobs | Ball requirements and forces | jacobst@uci.edu | (949) 330-9998 | Senior | 2 |
| 3 | Jordan Schmitz | Measurement equipment and forces | schmitzj@uci.edu | (949)547-3431 | Senior | 2 |
| 4 | Sherilyn Bumatay | | sbumatay@uci.edu | | Senior | 2 |

## 2.5 Experimentation Team

| # | Name | Role | Email | Phone |
|---|---|---|---|---|
| 1 | Wyatt Moscoso | Data Acquisition | wmoscoso@uci.edu | (909) 342-2669 |
| 2 | Tyler Jacobs | Data input | jacobst@uci.edu | (949) 330-9998 |
| 3 | Jordan Schmitz | Equipment | schmitzj@uci.edu | (949)547-3431 |
| 4 | Sherilyn Bumatay | Documentation | sbumatay@uci.edu | |

## 2.6 Project Costs Estimation

| Project Expense | Comments | Est. Amount ($) |
|---|---|---|
| Anthropomorphic Testing Dummy (ATD) | One week head and neck assembly ATD rental. Includes three ARS-12K angular rate sensors, and three 7264D-2K linear accelerometers. Fully certified components. | $3564 |
| Digital Air Gauge/pump | High precision | $45 |
| Velocity Speed Gun | | $78 |
| Adidas Soccer Ball | FIFA approved soccer ball | $30 |
| Mikasa Men’s Water Polo Ball | Men’s Olympic approved ball | $26 |
| | **Total** | $3743 |

## 2.7 Resource Estimation

| Name | Est. Hours (per week) | Rate ($/hr) | Est. Total ($) (per week) |
|---|---|---|---|
| Wyatt Moscoso | 8 | 40 | 320 |
| Tyler Jacobs | 8 | 35 | 280 |
| Jordan Schmitz | 8 | 35 | 280 |
| Sherilyn Bumatay | 8 | 35 | 280 |
| **Total** | 32 | 145 | 4,640 |

# 3 Project Risks and Communication

## 3.1 Risk Mitigation Plan

| Risk | Severity | Probability | Mitigation |
|---|---|---|---|
| Electrical shock | Low | Medium | Ensure when wiring dummy that no power source is connected. Be connected to ground. |
| Head trauma | Medium | Low | Ensure that during experimentation all members of the group are aware that |
| Lifting injury | Medium | Low | When lifting objects, be sure to lift with your legs, not your back. |

## 3.2 Communication Plan

| Communication Type | Audience | Frequency | Responsibility |
|---|---|---|---|
| Group meetings | Everyone | Weekly | Establish key tasks that need to be completed for upcoming experimentation. |
| Group Email | Everyone | Daily | Keep updated with ATD rentals and approvals. |
| Group Text message | Everyone | Daily | Keep updated on group progress. |
| 2014 Fall Design Review and Alumni BBQ | UCI professors, UCI students, industry professionals and UCI alumni | December 12, 2014 | Receive feedback on |

# 4 Additional Project Details

**From UROP Proposal:**

I am working with Doctor David Reinkensmeyer, Jordan Schmidt, Tyler Jacobs and Sherilyn Bumatay to remedy the lack of data for these two sports and ascertain the effects of ball pressure on chance of serious injury (TBI's). We would like to see if there is a way to lower the Gadd index and frequency of trauma occurrence through a new standardized pressure, and it is expected that an optimal pressure will be found to generate the lowest acceleration at each velocity – a "safe" pressure.

Furthermore, once the relationship between pressure and acceleration has been established, two main paths are clear. We will have data for comparison between the accelerometer and g-force tracker, which we can use to calibrate the tracker. We will also have data for which areas create the most danger for the head when impacted, and therefore will be in a good position to look into possible headgear modifications and design for these two sports. This headgear may significantly reduce the chance of TBI, and will be created based on the Gadd index comparison of impact points

**Methodology:**

This project will be carried out by shooting balls at a "crash-test dummy," otherwise known as an accelerometer device, in order to receive the impact and record the data. The accelerometer can accurately measure impact force and acceleration in 3 directions, as well as provide an accurate model of the surface elasticity, friction, and damping forces of a human head. This is a simplification, as all heads do not have the same elasticity or friction due to differing hairstyles, bone structure, facial features, and genetics. The scope of our experiment simply focuses on the variables of pressure and velocity. We can afford, therefore, for those extraneous values to be taken as constant in order to examine the sole effects of pressure and velocity on the frequency of TBI. This dummy will not only have 6 internal sensors that can measure forces, moments, and acceleration in the x, y, and z axes, but also will be outfitted with a prototype measuring device called the "G-force" tracker. This tracker offers the exact same types of data collection that the sensors inside the dummy do, but has yet to be fully tested on actual players. Therefore, a part of the experiment will be comparing the reliable accelerometer data with the G-force tracker data in order to determine its overall precision. The G-force tracker will be our "variable" with our "control" being the accelerometer sensor outputs.

The ball's path and speed will be generated and held nearly constant through the use of a ball launcher. This launcher, usually used for the soccer team's practice, has been proven to have very high accuracy and precision. Through empirical testing, once lined up, 8 out of 8 shots hit a designated point on the crossbar from over 18 yards away. This means that the x, y, and z components of the path of the ball is nearly accurate, albeit for a small set of data, even with wind factored in.

The layout of the experiment in terms of pressure and velocity ranges is taken from studies on average ball speeds and ball pressures in competitive play. Soccer ball speeds range from 45 to 55 miles per hour, while water polo ball speeds range from 41 to 54 miles per hour (Spiotta et).

Al). Pressures vary from 12 to 16 pounds per square inch. Therefore, we will set our testing distribution for speeds for soccer will be from 45 to 55 every 2 miles per hour at each integer of psi from 12 to 16. For water polo, we will make the speed range from 41 to 55, again staggered every 2 miles per hour.

The data will be compared through use of the Gadd index, as well as our calculations of moments about the neck and forces to the head. Histograms will be used to determine the outliers in terms of magnitude of Gadd number, and can be used to simplify the processing of the many impacts that will be recorded.

**Student Responsibilities**

It is my responsibility to research all relevant variables and make all necessary preparations for the experiment. I must conduct the experiment in the most controlled environment possible. Then, it will be my job to analyze any data received and condense the data into easily interpretable forms. It is my responsibility to also write a thesis on this material and present my research findings in the 2015 UCI UROP symposium. It is also my responsibility to maintain good communication throughout the course of the research with my advisor, Doctor Reinkensmeyer, about all developments.