

RHEOFLEX

UVA E-Cup Concept Submission

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RHEOFLEX: a new type of brace to reduce knee injury in football

RHEOFLEX is a knee brace for football players that provides flexibility when they want it, but protection against ACL, MCL, and LCL injury when they need it. The end-user of a RHEOFLEX knee brace will be football players who want to prevent potentially career-ending knee injuries. Currently in the NFL, the players that are at the highest risk for such injuries wear little to no protection around the knee because it impedes their performance. The value proposition of the RHEOFLEX knee brace is that while it reacts to situations that cause debilitating knee injury, it is also flexible enough in its inactive state to not hinder the athlete's performance. Further, after successfully integrating this technology into knee braces, RHEOFLEX can create equipment that prevents injury in various other high speed or impact situations.

Problem: Knee injury is the most common injury in the NFL

On average, a division one college or professional football team witnesses four players undergo knee injury and surgery per season. ACL and MCL injuries are common in a game where players land harshly after a big catch, cut sharply to avoid tackles, and receive tremendous blows to the lower body from their opponents. Season ending injuries such as these can take the difference-making player out of the game at a clutch moment, deflate the hopes of making the playoffs and in the worst cases, end a player's career far short of what it could be.

In most cases of knee injury, the players are not wearing any type of brace or protection on their knees. Currently, other knee braces that claim to reduce the likelihood of knee injuries do so by sacrificing mobility. Typically, the more protective a brace is, the less movement and flexibility it allows, and performance is so important in the sport that players will not wear knee braces if it will affect their play. Herein lies the unmet need that RHEOFLEX addresses.

Value Proposition: The RHEOFLEX knee brace reduces knee injury without sacrificing performance

RHEOFLEX keeps a player's knees intact and on the field by counteracting forces that would cause a tear or strain on crucial knee ligaments, . Additionally, RHEOFLEX only protects when it needs to, allowing players full mobility when not in a hazardous situation.; With RHEOFLEX, players no longer need to choose between performance and safety. RHEOFLEX's technology allows players to make the game winning catches, breakout cuts and even absorb a nasty low tackle while protecting his knee against serious injury.

RHEOFLEX protects a player's career, saves thousands of dollars in salary, scholarships and medical bills, and protects a team's reputation.

Product Description: The RHEOFLEX knee brace acts against the force of knee injury by using electroactive polymers

The mechanism of injury in ACL and MCL injuries is an inward bending of the knee called valgus stress as seen in Figures 1 and 2. The RHEOFLEX knee brace protects against this mechanism of injury by using electroactive polymers that contract upon electrical impulse. Once the player receives a blow or exerts an amount of force through his knee capable of tearing a ligament, the brace sends an electric current through the stabilizing materials within. When exposed to an electric current, the electroactive polymer, commonly referred to as an 'artificial muscle' material, will tense

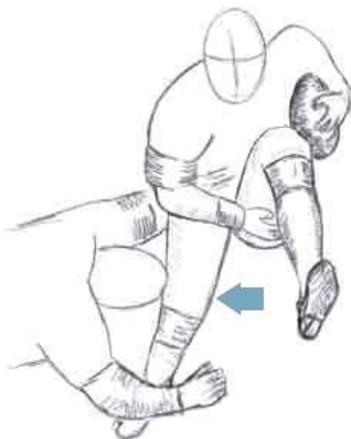


Figure 1: Depiction of a Football Hit Causing Valgus Stress

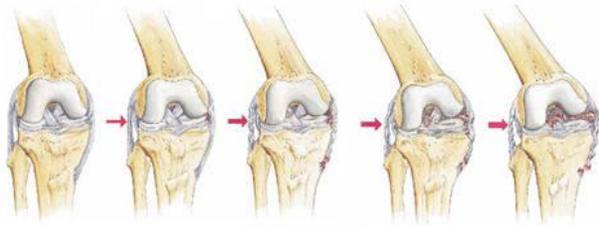


Figure 2: Valgus Stress Resulting in MCL Tear (Dunitz, 2001)

up and constrict. When secured above and below the knee, a constriction of this type of material will cause a force that straightens the valgus bending of the knee and resists the bending that would cause ACL and MCL injury. The materials needed to produce such a brace are neoprene for the anchor rings, a high current rechargeable battery for the power supply, small amounts of plastic for the housing and anchor points, and the artificial muscle material. A couple companies currently exist using electroactive polymers as

actuators; Artificial Muscle, Inc. specifically has this technology available for licensing. The company claims cheaper, smaller, and more efficient actuators, or “muscles”, than the traditional electromagnetic actuator, which we have found even small actuators retailing at \$29 can produce up to 250 pounds of linear force, which is 50% of the force that a knee can safely withstand on its own.

Market Opportunity: Knee injuries result in an annual \$204 million in lost salary and scholarships

Both college and pro football teams currently pay to outfit their players with protective gear. The average college knee brace runs for about \$600 (Donjoyglobal.com). At this price, to outfit each skill player (not linemen) with a pair on every team in the NCAA’s division one and the NFL’s 32 professional teams would cost \$28.3 million. Since a serious knee injury is likely to end a player’s season, college teams lose, on average \$46,650 in scholarship funds per season to serious knee injuries, while professionals lose \$3.8 million in salary. Yet, in 2013 NFL teams averaged 5.94 ACL and MCL injuries. This gives us a total market value of \$204 million just in salary and scholarship lost to knee injuries. See *exhibit 2* for further details on these calculations. Note that this value is before costs of surgeries, rehabilitation, and loss of fan interest when star players are inactive.

RHEOFLEX has broken this mold and simultaneously allows the wearer full mobility and full protection; it is a new technology, truly incomparable to existing solutions. Market success for RHEOFLEX relies on two main objectives: completing product development and attracting the early adopters.

Personal connections in the UVA athletic training department with a team orthopedic surgeon and head athletic trainer are the first avenue of the market to be pursued. The UVA football team would serve as a proof of concept as well as a first client. Ideally, this will be achieved within the 2016-2017 football season. After RHEOFLEX has become the brace of choice for the team, we would like to partner with a sports knee brace market leader, most likely Donjoy, on a licensing agreement. Donjoy is the leading competitor and has largely captured the sports brace market; however, they do not have a brace that currently meets the performance and protection needs of skills players. Two seasons from that point, RHEOFLEX aspires to be the knee brace of choice for 10% of this identified market. At this point, two years from first adoption, RHEOFLEX will begin to develop other products using their innovative technology. The technology behind RHEOFLEX has many different potential applications including bracing other limbs and joints of the body in high impact situations like soccer, hockey, motorsports, and flight. Within three years, RHEOFLEX aims to penetrate three new markets, while maintaining strong presence and growth within the football knee brace market.

Critical Success Factors & Risks: Stages to full development of RHEOFLEX

- Continued market research and in-depth interview for market adoption
 - Athletic Trainers for injury prevention
 - Players for product use and interest in use
 - Coaches for incorporation in team aspects
 - Equipment coordinators for care and ease of use
 - Team administrators on how and what they currently purchase for knee protection
- Development of the RHEOFLEX prototype
 - Acquisition of electroactive actuators
 - Validation that contraction will prevent injury using verified artificial knee for ligament injuries
 - Electroactive actuator response time is within time range that injury occurs
- Partnership or funding to scale up manufacturing capabilities
- Marketing RHEOFLEX to effectively penetrate the football knee brace market

Management Team

Tim Barry is a 4th year Biomedical Engineering major with a minor in Physics. He has experience in sports biomechanics and materials science. Steve is a 4th year Commerce student with concentrations in Finance and Management, an Entrepreneurship track, and a second major in Economics. Pearson Gean is a 4th year Biomedical Engineering and Economics major with experience in sports biomechanics research, including gait analysis using Donjoy knee braces.

Addendum: Team Member Biographies

Tim Barry:

4th year Biomedical Engineering major and Physics minor. Tim brings a lot of technical and work experience to RHEOFLEX. At UVA, Tim has worked in a Biomedical Engineering Lab for 3 semesters on a project funded by DARPA. That lab work used motion biomechanics to analyze running and climbing biomechanics for injury risk. Tim is also a member of Health Unbound and went through the Biotrep mentoring program to help prepare the team for the E-Cup. Tim's work experience involves being a tech in a machine shop, contributing a lot of hands on technical skills in design and prototyping. This past summer, Tim interned with a tech start-up in Arlington, VA doing competitor research, IP search, and inbound marketing. Tim's skills will help with the Leadership and Tech Transfer portion of making RHEOFLEX a product that the market and the direct users will want. Through extensive efforts on this idea already this semester, Tim has worked with a number of individuals to build RHEOFLEX in to the best company it can be; these individuals include Professor Mathew Panzer, PhD, of the Mechanical Engineering Department and Center for Applied Biomechanics who works with impact injury biomechanics, Michael Straightiff of the UVA Patent and Venture group on developing and protecting IP behind RHEOFLEX, Professor Jim Fitz-Gerald, PhD, of the Materials Science Department on optimal material selection, the Biotrep mentorship group including Shaun Moshasha and Alex Zorychta who won the E-Cup in 2012, and Keren Ziv, CSO at CytoMag LLC and former Stanford Researcher who provided valuable insight in to tech start-up angel investing, market research, and validation techniques.

Pearson Gean:

4th year biomedical engineering and economics major. 3 years of experience in sports biomechanics research including: MRI based finite element modelling of the lower limb musculature to explore causes of hamstring injury; gait analysis of total hip/knee replacement patients before and after surgery; gait analysis of healthy individuals wearing Donjoy knee braces with different restrictions on range of motion under the chair of the orthopedic department for the University of Arkansas for Medical Sciences. A member of the 2012 ACC championship swim team and former All-American swimmer. Former 2 time state champion and NCAA division 1 recruited quarterback.

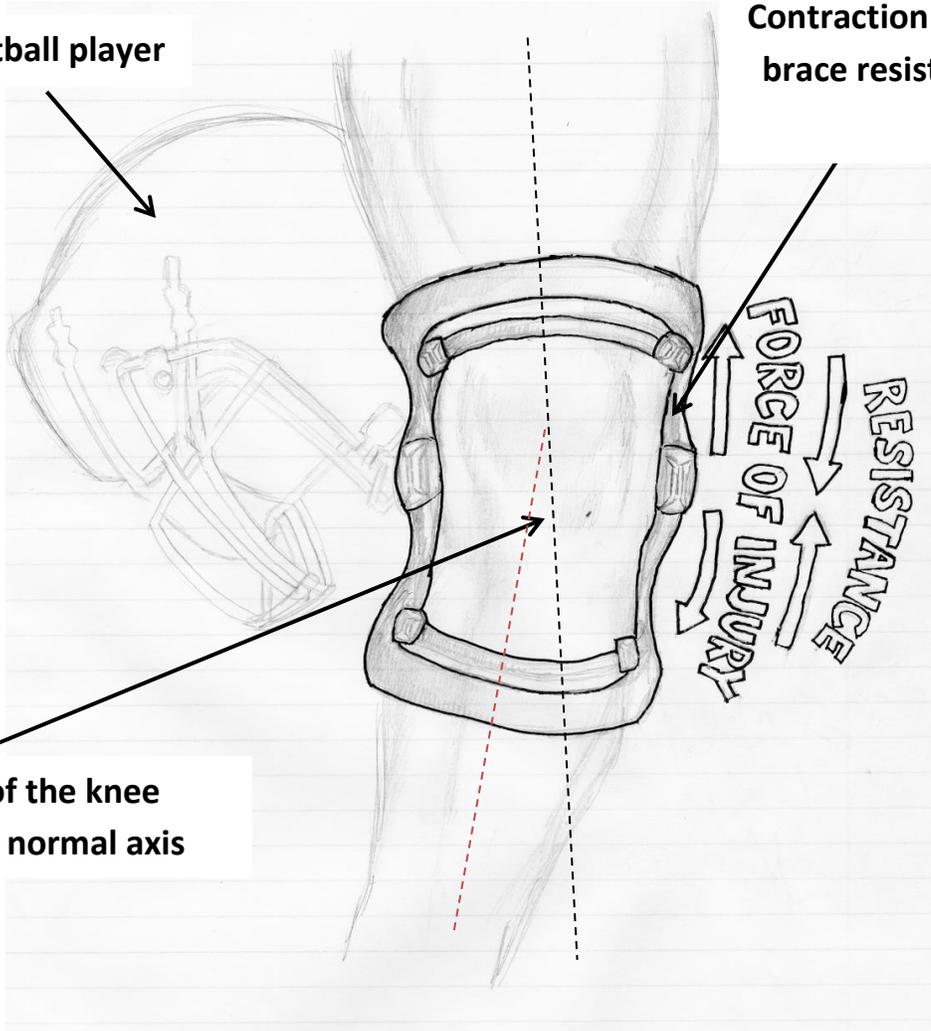
Steve Simion:

4th year Commerce student with concentrations in Finance and Management, an Entrepreneurship track, and a second major in Economics. Steve has accepted an offer from Wells Fargo Securities, where he interned this past summer, to work as a Financial Analyst in Energy and Power Investment Banking starting June 2015. Prior to employment at Wells Fargo Securities, Steve worked at RamQuest Software Inc. At the University, Steve was a founder and the first president of the University's Tau Kappa Epsilon chapter. He also volunteers for CASH - an organization that offers free tax service to those in the lower income bracket.

Exhibit 1

Hit from a football player

**Contraction of RHEOFLEX
brace resisting sideways
bending**



**Valgus bending of the knee
compared to the normal axis**

Exhibit 2: Research estimates \$28.3 million spent in professional and college knee brace market

	Professional	College	Totals
Average player salary / scholarship	\$1,900,000 ¹	\$23,325 ²	
Games played	16	12	
Games missed per injury	8 ³	6 ³	
Cost of injury to avg. player	\$950,000	\$11,663	
Preventable injuries per team per season	5.94 ⁴	5.94 ⁴	
Team cost of preventable injuries	\$5,640,625	\$69,246.09	
Teams	32	340	
Preventable cost in market	\$180,500,000	\$23,543,672	\$204,043,672
Targeted players	1068 ⁵	22481	
Targeted players per team	33.38	66.12 ⁶	
Current knee brace cost	\$1,200 ⁷	\$1,200 ⁷	
Teams	32	340	
Total Market	\$1,281,600	\$26,977,075	\$28,258,675

¹Average salary of an NFL player as quoted by Bloomberg, Business Insider and Forbes, 2013

²Average value of a scholarship in the nation's top 10 programs according to USA Today's subsidiary The Big Lead, 2013

³We assumed that players were equally likely to suffer a serious knee injury at any point in the season. These injuries, which could be prevented with RHEOFLEX, make a player inactive for the rest of the season. It logically follows that the average knee injury should result in missing half the games in a season.

⁴The average number of preventable injuries per team is based on the number of 2013 ACL and MCL tears, documented on NFL.com. These injuries could have been prevented with RHEOFLEX and end a player's season.

⁵Number of active players in the NFL, this current 2014 season, who are both active and play a skill position – skill positions include, quarterbacks, running backs, wide receivers, tight ends, linebackers and defensive backs – according to NFL.com

⁶To estimate the number of college players eligible for the brace, we scaled up the average number of pro players eligible for the brace by the ratio of allowed rosters (105 for college to 53 for professional.)

⁷Estiment from USA Today and Indianapolis star for cost of knee braces for college teams