Biomedical Advancements in Injury Recovery, Performance Enhancement, and Mechanical Assistance Applied to Athletics

A Senior Project

presented to

the Faculty of the General Engineering Department

California Polytechnic State University, San Luis Obispo

In Partial Fulfillment

of the Requirements for the Degree

Bachelor of Science

by

Matthew Russell

March, 2013

© 2013 Matthew Russell
# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>List of Figures</td>
<td>4</td>
</tr>
<tr>
<td>Abstract</td>
<td>5</td>
</tr>
<tr>
<td>Introduction</td>
<td>6</td>
</tr>
<tr>
<td>Background/Literature</td>
<td>8</td>
</tr>
<tr>
<td>Injury Repair Mechanisms and Methodologies</td>
<td>10</td>
</tr>
<tr>
<td>Platelet Rich Plasma (PRP) Injection</td>
<td>10</td>
</tr>
<tr>
<td>Frequency Specific Microcurrent</td>
<td>14</td>
</tr>
<tr>
<td>Biodegradable Silk Matrix for Anterior Cruciate Ligament (ACL)</td>
<td>16</td>
</tr>
<tr>
<td>Performance Enhancement Mechanisms and Methodologies</td>
<td>18</td>
</tr>
<tr>
<td>Erythropoietin Gene Therapy</td>
<td>19</td>
</tr>
<tr>
<td>Insulin-like Growth Factor-1 (IGF-1) Gene Therapy</td>
<td>20</td>
</tr>
<tr>
<td>PPAR-Delta and GW1516 Metabolic Rate Accelerator</td>
<td>22</td>
</tr>
<tr>
<td>Mechanical Assistance Technology</td>
<td>23</td>
</tr>
<tr>
<td>Össur Flex-Foot Cheetah</td>
<td>24</td>
</tr>
<tr>
<td>Ottobock Genium</td>
<td>26</td>
</tr>
<tr>
<td>Design</td>
<td>28</td>
</tr>
<tr>
<td>Running the Program</td>
<td>28</td>
</tr>
<tr>
<td>Java Swing</td>
<td>29</td>
</tr>
<tr>
<td>Main.java</td>
<td>29</td>
</tr>
<tr>
<td>MainFrame.java</td>
<td>30</td>
</tr>
<tr>
<td>MainView.java</td>
<td>30</td>
</tr>
<tr>
<td>Conclusion</td>
<td>33</td>
</tr>
</tbody>
</table>
Program Code.................................................................33
Main.java.................................................................33
MainFrame.java.........................................................34
MainView.java...........................................................34
References...............................................................40
Appendices...............................................................44
  Appendix I..............................................................44
  Appendix II.............................................................45
  Appendix III..........................................................46
  Appendix IV............................................................47
  Appendix V.............................................................48
  Appendix VI...........................................................49
  Appendix VII..........................................................50
List of Figures

Figure 1 ..............................................................................11
Figure 2 ..............................................................................12
Figure 3 ..............................................................................13
Figure 4 ..............................................................................16
Figure 5 ..............................................................................18
Figure 6 ..............................................................................21
Figure 7 ..............................................................................23
Figure 8 ..............................................................................25
Figure 9 ..............................................................................26
Figure 10 ..........................................................................27
Abstract
Athletics is constantly changing, and athletes are continually getting bigger, faster, and stronger. At the same time, biomedical technology and innovation is rapidly developing. New methods of injury recovery, genetic enhancement, and prosthetic assistance are being assimilated into the athletic world. The up and coming athlete needs to be aware of all of the usable information around them. This project is an accumulation of some of the cutting edge advancements in those fields. Platelet Rich Plasma Injections, Frequency Specific Microcurrent Treatment, and Silk Polymer Anterior Cruciate Ligament Replacement are innovative new ways to treat common sports injuries. Performance enhancement has increased to new feats of gene doping Erythropoietin hormone, Insulin-like Growth Factor 1 hormone, and orally consuming PPAR-delta modulator compound. The Ossur Flex-Foot Cheetah and Ottobock Genium prosthetics have allowed athletes to compete at the highest level possible despite traumatic injury or birth defects. The design aspect of this project is a prototype for a website in the form of a local program, created in Java, with a graphical user interface. This prototype allows the user to make selections of their sport of interest and their desired field of study, and then outputs the information of the newest innovation applicable.
Biomedical Advancements in Injury Recovery, Performance Enhancement, and Mechanical Assistance Applied to Athletics

Introduction

The entirety of athletics has rapidly evolved over the years. Within the last century athletes have progressed physically at an alarming rate. The 100 meter dash record has changed from 10.8 seconds in 1891 to 9.58 seconds in 2009 (100M Men, 2012). In Major League Baseball, the career homerun record has increased from 714 by Babe Ruth in 1935, to 755 by Hank Aaron in 1976, and then to 762 by Barry Bonds in 2007 (Overall Baseball Leaders, 2011). In the recent summer Olympic Games of 2012, Oscar Pistorius of South Africa was the first Paralympic athlete to compete in the Olympic Games. The world watched a man, who at a previous time would have never dreamed to compete for Olympic gold, run with prosthetic assistance on the biggest stage of his life. So, not only has the physiological limitations of athletes changed, but the technological assistance of athletes has changed as well. With the continuing advancements in technology and biomedical breakthroughs, it is hard to determine where the limitations of future athletes will end up.

In a world where athletics and technology is consistently changing and advancing, how does the athlete of the future stay up to date about the advantages at his or her disposal? Furthermore, how does the future athlete stay informed about the pitfalls of illegal enhancement surrounding them? Barry Bonds, Alex Rodrigues, Shawne Merriman, Bill Romanowski, Marion Jones, Ben Johnson, Fernando Vargas, and Shane Mosley are all known for breaking records and pushing the limits of their respective sport, however; they are also known for their illegal use of performance enhancing
methodologies. Whether it is for rapid injury recovery or just to get a leg up on the
competition, performance enhancement and medicinal recovery can be dangerous and it
is up to the athlete to become informed on legality and safety. Information is power when
the injured athlete is searching for the fastest recovery mechanism during a fasted paced
season. And amidst the wreckage of technological controversy in sports, where does the
athlete in need of prosthetic assistance go to find help? An information hub for athletes is
in desperate need. Athletes need to be informed about the biomedical technology at their
fingertips, and they need to be warned about the possible dangers it can have on their
careers.

In order to inform the future athlete about the latest recovery techniques available,
the possibly illegal enhancements on the horizon, and the newest mechanical
breakthrough in prosthetic assistance; a one stop, easy access database needs to be
created. This system needs to be designed to conform to the specific details of each
individual sport and desires of each individual athlete. The design also needs to
incorporate the media driven technological standards of the athletic environment. The
future athlete should be equipped with the knowledge to make positive decisions for their
athletic endeavors after using said system.

The intent of this project is to design a prototype of a website in the form of a
graphical user interfaced local program for the future athlete. This program will
incorporate a screening process designed to bring the athlete information detailed to their
unique sporting specifics. With a few tailored questions and a few clicks, future athletes
will have information about the latest cutting edge bioengineering repair methods for
injuries, informative guidance about the future of genetically engineered enhancements,
and details about advanced prosthetics for the athlete looking to continue their sporting endeavors. Through the use of Java, this program will contain information about the latest technology in prosthetic design, the newest developments in genetic and stem cell physical enhancement, and some of the injury recovery mechanisms and methods new to public use.

In theory, this site would allow the injured athlete easy access to information about the possibly fastest recovery mechanism. This site would also inform the up and coming athlete about the newest enhancement techniques in order to avoid ignorant pitfalls in their athletic career. Lastly, this site would bring hope to the athlete looking for biomedical help to continue competing.

This report will discuss research on three categories of biomedical engineering and technology. These categories include injury repair mechanisms and methodologies, genetic enhancement through gene doping, and mechanical assistant via prosthetic design. The design of the Java program will be disclosed and discussed along with the methodology and applications. Data will be collected and discussed, as athletes from soccer, tennis, football, baseball, and track and field use the program to acquire information. Overall, this project will seek to accumulate and distribute information for the benefit of athletics and the future athlete.

**Background/Literature**

The world of sports is very demanding and extremely fast paced. During the 2012/13 NFL season, 49er quarterback Alex Smith sustained a concussion in the third game of the season and was quickly replaced by Colin Kaepernick. Smith had four touchdown passes, 304 yards throwing, and quarterback rating of 80% over two games,
however; Kaepernick stepped in and took the position for the remainder of the season even though Smith was only ineligible to play for one week (Alex Smith, 2013). What if Alex Smith would have been able to recover more quickly? Would he have been able to keep his position? Adrian Peterson, running back for the Minnesota Vikings, suffered a torn anterior cruciate ligament during the 2011/12 season. While Peterson had an All-Star performance this 2012/13 season, could it have been better if he had been able to rehabilitate sooner from his tear? When time and performance is money in the arena of professional athletics, all of these questions and possibilities must be addressed.

There are also the athletes who illegally use performance enhancing drugs and cost their teams, sponsors, and themselves thousands of dollars. Would these players make the same decision had they known the future outcome? In recent news, Lance Armstrong revealed that he used performance enhancements during his reign of Tour de’ France victories. Due to his usage, Armstrong was stripped of his titles, banned from competition, released of his 75 million dollar endorsement contract, and forced to step down from the Livestrong Cancer Charity (Litke, 2013). When it comes to making decisions about performance enhancement use, athletes need to understand the magnitude of their decisions.

Biomedical study has quickly progressed since “Y.C. Fung played an important role in the establishment of biomechanics as a modern, rigorous discipline, primarily through the publication of an influential series of books on biomechanics” (Ethier, 2007, p. 13). Biomechanics, bioengineering, genetic engineering, tissue engineering, and many other studies have contributed greatly to the medical world, as well as the professional
Injuries are the nemesis of athletes and therefore endless time, funding, and research is devoted to injury repair and rehabilitation methods. The more quickly an athlete can get back to work the better, and with the intensity of sports today, injuries happen often. Many new techniques and methods are on the horizon for athletic injury recovery.

**Platelet Rich Plasma (PRP) Injection**

Platelet Rich Plasma Injection (PRP) has been used in operating rooms for decades to assist in the healing process of wounds or in certain surgery operations, such as Spinal Fusion Surgery (Mishra et al., 2009, p.113). PRP is a dense concentration of platelet cells, originating from the blood, and separated by a centrifuge. Platelet cells from the blood have growth factors which are essential for the natural physiological healing process. A growth factor is usually a steroid hormone, or a protein, which acts as a signal within the body between cells to stimulate cellular growth (Tymoczko, 2013, p.260). When PRP is injected into afflicted areas, the increase in growth factor stimulates increased cellular response and therefore healing.
Platelet Rich Plasma Injection is a method sourced from the patient seeking treatment. The patient’s blood is drawn, usually from the median cubital vein of the arm, and the blood is placed in a centrifuge. The centrifuge spins the blood at high speed to separate it into leukocytes, erythrocytes, blood plasma, and platelets. The platelet layer is obtained and then injected into the injured area. Sometimes, the PRP injection is supplemented with an activating agent of either thrombin or calcium chloride. These activating agents serve to catalyze the healing process by acting like coagulant factor enzymes in the injured area (Mishra et al., 2009, p.116).
Fig. 2. The basic mechanisms for preparing PRP involve (A) withdrawal of the patient’s peripheral blood and (B) centrifugation to obtain a concentration of platelets and cytokines. (C) The centrifuged product is stratified into 3 layers.


While originally PRP was used in operating rooms for surgical recovery, innovative techniques and advancements in this method have led to its use in the orthopedic department of sports related injuries. Platelet Rich Plasma Injections have begun to be used in Achilles tendonitis, Rotator Cuff tendonitis, “Tennis Elbow,” and Patellar Tendonitis. Tendonitis is professionally stated as “a tendon injury resulting from repetitive mechanical load with a subsequent inflammatory response” (Almekinders, 1998).

Achilles tendinitis is a common injury in sports strictly focused around running, such as track, marathons, and cross-country. This injury is the result of a microscopic tear in the Achilles tendon, which if not treated immediately, can progress into a macroscopic tear requiring surgical repair (Almekinders, 1998). When a microscopic tear is present, PRP injection is inserted into the torn region of the Achilles tendon and thus stimulating increased growth factor to the area. Commonly, Achilles tendinitis recovery time is
between 6-8 weeks with ice, rest, and compression; however, with PRP, studies show a 50% reduction in recovery time to three to four weeks (Lopez-Vidriero, 2009, p.275).

Rotator cuff tendonitis and “Tennis Elbow”, otherwise known as elbow tendonosis, can be common injuries of baseball, tennis, golf, volleyball, swimming, or other sports with repetitive throwing, swinging of the arm, or “flicking” of the wrist. Elbow tendonosis is caused by small tears in the tendons that attach the forearm muscles to the arm bone at the elbow joint (Lopez-Vidriero, 2009, p.273). Rotator cuff tendonitis occurs when there is inflammation of the rotator cuff tendons and the bursa that surrounds these tendons. PRP injection can reduce the recovery process by as much as 50% in these common injuries as well with insertion into the torn tendon area (Lopez-Vidriero, 2009, p.273).

Patellar tendonitis is a common injury to the knee area in athletics with excessive jumping. Basketball, volleyball, track and field jumpers, and sometimes football players
can be victims of Patellar tendonitis. This injury is brought on by inflammation in the inferior patellar region (Almekinders, 1998). Prolonged use can then result in tears to the patellar tendon. Some studies show that stiff ankle movement and ankle sprains contribute to patellar tendonitis (Lopez-Vidriero, 2009, p.274).

**Frequency Specific Microcurrent**

Frequency Specific Microcurrent is a rapidly developing process to treat nerve or muscle pain, due to damaged tissue or muscles. Cells in the human body produce current in milliamps, while microcurrent is current on the order of 1/1,000,000 of an amp (Webster, 2010, p.265). “Each cell, tissue and organ has an ideal resonant frequency that coordinates its activities” (Oshman, 2011). Specific frequencies induce specific effects for different physiological components of the human body. Where nerves might have an ideal resonant frequency, muscle tissues of the ankle might have another. While physioelectric therapy has been around since the late 1960s and early 1970s, it has not been until recent discoveries that specific frequencies are used for different muscle, tissue, and nerve groups within the body (Webster, 2010, p.269).

When microcurrent is passed through tissue at its specific resonance frequency, the ATP production within the tissue cells is increased. With an increase in the basic physiological energy unit, the physiological processes greatly increase in rate and production. Cell formation increases, which, in turn, assists in rapid healing processes. Protein synthesis and intracellular waste removal also increases, which add to the increased healing rate (McMakin, 2003, p.146). By compression, strain, or stretching, tissues or muscles can become torn and then inflamed. Inflammation and tearing alters the specific resonant frequency of the tissues and muscles (McMakin, 2003, p.143).
When microcurrent is passed through the inflicted area at the correct frequency, the inflicted tissue and/or muscles can be resynchronized to their optimal resonant frequency. This instantly increases the ATP production and healing processes as stated before (Curtis et al., 2010, p.2).

Frequency specific microcurrent can be used in multiple areas of injury that would be useful in athletics. It can be used as a post-op treatment for ligament, tendon and scar tissue repair, or it can be used as a primary source of injury treatment for disc pain, back or lumbar injury, strains, and tendinitis. A common injury to almost all sports is lumbar pain of some sort. With the many biomechanical stresses and strains of weightlifting and competition, lumbar and back injury is fairly common. A common cause of this pain is myofascial trigger points (MTrPs). Depending upon the location of the MTrPs, the back pain can be in the vertical cervical, horizontal rectus abdominus, or gluteus medias/lumbar hip region (Curtis et al., 2010, p.6). “Myofascial pain can be severe and debilitating, and can cause restrictions in normal biomechanical joint function, impairment of neurological function, and impairment of circulation and lymphatic flow” (Long et al., 1996, p.50). As an athlete this kind of injury can be sidelining for weeks, but more often than not, months.
With FSM, a back injury, as described earlier, can be rehabilitated to full health very quickly by the body’s naturally healing techniques after the stimulation. Treatments consist of a 30-40 minute session of low amperage microcurrent through the low back twice a week for four weeks. In a study of 138 patients, all of which with pain ratings 6-8 on a scale of 10 with 10 being the most painful, 127 patients were reported with pain ratings 0-2 after the four-week session (McMakin, 2003, p.149). The Frequency Specific Microcurrent is capable of returning athletes to the field faster than traditional methods of recovery for chronic low back myofascial pain and other similar injuries.

**Biodegradable Silk Matrix for Anterior Cruciate Ligament (ACL)**

The tearing of the anterior cruciate ligament (ACL) in the knee, unfortunately is a common injury in athletics. This recovery must be executed through the use of arthroscopic surgery and, contrary to common diction, the ligament can not be repaired, but must be replaced. There are two methods consistently used to replace the torn
ligament: autograph, which is the grafting of another ligament from the patient’s own body, or allograft, which is the grafting of a ligament from a donor’s body (Hoehn, 2011, p.691). The most common ligaments used to replace the native anterior cruciate ligament are the hamstring tendon and the patellar tendon. Hamstring grafts are accomplished by braiding together the hamstring semitendinosus tendon with an accessory adductor tendon, and then attaching to the tibia and femur with screws (Hoehn, 2010, p.692). The patellar graft is completed by removing the inner two-thirds of the patellar tendon and attaching it to the tibia and femur with screws as well (Hoehn, 2010, p.692). It was not until recent biomaterial advances that synthetic poly-silk fibers have been used for anterior cruciate ligament repair.

With so many injuries to the anterior cruciate ligament, and the limited clinical options available to repair the ligament, innovation is necessary to help the recovery process. The necessity to quickly return full range of motion and full force capacity on the ligament has led to engineering solutions with biomaterials. ACL tears most commonly result in agonizing pain, discomfort, and little to no mobility. These conditions prohibit participation in sports or exercise of any kind for extended periods of time by current recovery rates (Lu, 2005, p.4808). The previously described methods of recovery have tendencies to form tendinitis due to the poor healing qualities of both hamstring and patellar tendons. However, silk-fiber matrices can be a suitable replacement for ligament replacement. The silk matrix is designed and tissue engineered to be equitable to the native ACL in mechanical properties, including fatigue. In order to mirror the mechanical properties, a rope design is used with the silk fibers. Costello’s equation for three stranded ropes was used to derive a multi-leveled silk fiber matrix that
could be equitable to the stress-strain curve of human anterior cruciate ligaments (Altman, 2002, p.4132).

![Fig. 5. Schematic of an ACL 6-cord matrix hierarchy.](image)


The matrix of the silk polymer strands is designed such that the native human cells local to the artificial ligament can grow into the matrices. This design significantly increases the capability to mirror the natural knee stiffness, yield point, and elongation at break. The actual cells that can physiologically attach to the artificial ligament are the bone marrow stromal cells. Recent tests have returned data showing silk fiber ligaments enduring three million cycles of stress and strain before failure (Altman, 2002, p.4138). These results show promise for biomaterial replacement of ACL tears.

The exchange from human hamstring or patellar tendon to silk fiber replacement will result in significant recovery time decreases for anterior cruciate ligament tears. Early data has shown a three month recovery period with silk fibers in comparison to the standard six month recovery with common methods. A 50% decrease in recovery time could salvage a season that could have been lost for an athlete suffering from ACL tear.

**Performance Enhancement Mechanisms and Methodologies**

In the very competitive world of sports today, the athlete who is faster, stronger, and better conditioned is king. Natural means of increasing strength through weight
training or conditioning are no longer fast enough to keep pace with the most competitive players. As biomedical knowledge assimilates into the sporting world, methods for enhancing performance medically, and even genetically, rapidly take form. The legality of these methods have yet to be determined in some cases, however athletes need to be aware of what enhancement methods are circulating or on the horizon.

**Erythropoietin Gene Therapy**

While the use of Erythropoietin (EPO) is not relatively new, the gene therapy mechanisms to make its use more efficient and difficult to trace are a recent breakthrough. EPO is a glycoprotein hormone that sends signals to the red blood cells. When these signals are sent from the EPO glycoproteins to the red blood cells, the red blood cells increase production (Tymoczko, 2013, p.243). By adding an abundance of EPO to the human biochemistry, an abundance of red blood cells are produced. An increase in red blood cells allows for more oxygen to be carried throughout the body, and thus, physical endurance increases, while fatigue decreases (Indiveri, 2002, p.5).

The use of EPO in the athletic arena is one form of blood doping. The oxygen delivery system of the human body including lung function, heart stroke volume, and vascularization are all limiting factors to endurance and well as the performance of muscle activity. Therefore, when an athlete can increase the efficiency and production of their oxygen delivery system, their performance can also increase (Tymoczko, 2013, p.240). This is why EPO has been commonly found in such endurance sports as biathlon, triathlon, distance running, and especially cycling.

In the 1990s, EPO increase in the body was conducted through blood transfusions. The patient would have blood drawn, allow the body to naturally produce red blood cells
back to the natural limit, and then inject the drawn blood back into the body to increase the EPO and red blood cell count. In the early 2000s this method became traceable by urine test, and drugs designed to increase EPO count were produced to counter the testing method. However, this orally consumed EPO initiator became traceable through blood testing methods (Ethier, 2007, p.150).

The newest method to increase red blood cell and EPO production is put into the body through gene therapy methods. The gene for EPO hormone conductors is isolated in bone marrow. Once isolated, the gene is replicated and attached to a DNA vector where it is injected back into the human body (Gauglitz, 2011, p.1471). The vector helps the gene penetrate into the human cells and the gene is then coded into the cell’s DNA. The natural DNA replication methods of the cells take over and produce increased amounts of the newly injected EPO conductors, thus EPO levels increase and, with it, red blood cell count (Indiveri, 2002, p.7).

**Insulin-like Growth Factor-1 (IGF-1) Gene Therapy**

In the human body, especially during adolescence, the insulin-like growth factor 1 (IGF-1) hormone works to help the growth development of the body. The insulin-like growth factor is a hormone coded by the IGF-1 gene and when the quantity is increased in a developed adult, it has anabolic effects (Tymoczko, 2013, p.514). Like EPO doping, IGF-1 has been in circulation in the athletic community for some time. However, recent developments in gene therapy have increased its untraceability.

The human body releases growth hormones into the blood, which then activates the release of IGF-1 hormone. The IGF-1 hormone stimulates the systemic growth in the body and almost all cell types, especially skeletal muscle cells, which attributes to its use
in athletes. Much like insulin, IGF-1 hormone also regulates the growth of those cells by its own concentration levels (Tymoczko, 2013, p.372). The significant stimulation of skeletal muscle growth by IGF-1 is what is so appealing to athletics, as strength is important to success in most competitive environments.

Until recently, IGF-1 hormone had to be ingested orally, and consequently could be traced in blood tests. With the advancing developments of gene therapy, primarily for disease and cancer therapeutics, IGF-1 gene therapy methods have been created. IGF-1 has been significantly used in the attempt to heal epidermal wounds and, therefore, multiple gene implantation techniques have been created such as intracutaneous injection of DNA, liposomes, a gene gun or electroporation (Gauglitz, 2011, p.1743). “Gene gun is a technique used to penetrate the cellular membrane with which the gold or tungsten-coated particles carrying DNA plasmids are propelled into skin cells” (Gauglitz, 2011, p.1743). With the IGF-1 gene coded into the DNA plasmids, the IGF-1 gene is successfully inserted into the human DNA coding within the cell. The cells natural replication process then produces increased quantities of IGF-1 hormone in the body (LeRoith, 2007, p.303).

![Fig. 6. The actions of IGF1.](image-url)
When this growth factor protein was given to mice in studies, results have shown that the bulkier muscles of the mice contract much more easily and the muscle rebuild is faster (Wolfram, 2007, p.3). Therefore, in the instance of strength training, athletes with increased IGF-1 would be able to lift more weight easier and then rebuild those muscle fibers faster, thus increasing strength gains at a much faster rate.

**PPAR-Delta and GW1516 Metabolic Rate Accelerator**

One of the newest performance enhancing discoveries under development and testing is the PPAR-delta modulator compound, known as GW1515 or GW501516. This modulator compound essentially can activate PPAR-delta and AMP-activated protein kinase. The activation of these two proteins by GW1516 is the same activation that occurs during the metabolic activity from exercise (Wei, 2003, p.9117). Essentially GW1516 tells the body that it is exercising even though it is not.

Through these activation pathways a number of athletically beneficial results occur in the body. From the presence of GW1516, the body can increase its consumption of glucose in skeletal muscle cells, as well as, activate more gene expression of those skeletal muscle tissues (Wei, 2003, p.9118). The body also can express genes that code for the utilization of lipids as fuel sources at a higher rate (Wolfram, 2007, p.580). This accelerated gene expression changes the body’s metabolism to favor the burning of lipids for energy within the body instead of proteins for muscle or carbohydrates. Essentially,
the body would burn fat stores while increasing muscle cell production, allowing users to become more lean and stronger simultaneously.

![Figure 7](image)

**Fig. 7.** Compound 7 (magenta) docked into the active site of the PPARδ receptor crystallized with GW2433.


Many studies on the GW1516 modulator compound have been conducted on mice with relatively astonishing results. In a study in which mice were fed a high fat diet, the GW1516 modulator allowed mice to resist lipid mass accumulation (Sauerberg, 2007, p.1497). These same results in athletes would prove to be astounding in performance modification. Currently, the GW1516 compound modulator is available through oral consumption (Wei, 2003, p.9119). Because of this, the presence of this modulator can be tested for via blood sample if there is suspicion of ergogenic use.

**Mechanical Assistance Technology**

Biomedical application to modern technology has resulted in a variety of advanced prosthetics and mechanical assistance devices capable of athletic endeavors. Whether it is an athlete who has undergone a tragic accident or someone born with the
necessity for physical assistance, each person should have adequate equipment to strive for their athletic goals and aspirations. Some of the newest prosthetic devices available can allow these aspirations to be achieved.

**Össur Flex-Foot Cheetah**

Whether by birth or by a traumatic event, some athletes need transtibial or transfemoral prosthetics for assistance. Normal prosthetics can hinder the full range of motion a normal appendage would be capable of, or they can be mechanically unfit for the stresses, strains, and loads of athletic recreation (Cheetah, 2013). The Össur Flex-Foot Cheetah is a top of the line prosthetic built for athletic endeavors.

The Flex-Foot Cheetah, which is made by Össur, is a carbon fiber transtibial and transfemoral blade custom designed for sporting activities. The blade is only 18.1 ounces in weight and can be used by patients up to 335 pounds (Cheetah, 2013). Each blade is custom built for its patient based on impact levels. For someone who is very athletic and looking to compete in track and field, or a sport with high intensity running, the Impact Level 4: Sport/Extreme level would be used. This level is “designed to enable high impact sports and activities with repeated extreme level of impact on the foot” (Cheetah, 2013).
One of the breakthrough ideas about the Flex-Foot Cheetah is its patented energy storage and release system. The blade functions closely to the characteristics of a spring, taking kinetic energy, storing it as potential energy, and then releasing it as kinetic energy once again. The second breakthrough idea contributing the ingenuity of the Cheetah is the vertical shock absorption. The Flex-Foot Cheetah’s ability to absorb shock allows the natural limb, in connection to the prosthetic, to be safe as well as contributing to a more natural gait (Cheetah, 2013).

In a study, the Flex-Foot Cheetah was able to produce a mean running speed of 6.84 m/s. In that same study, the mean muscle power generated by the hip flexor of the leg with the Cheetah was 1,058 W, and the moment knee extensor was 170 N*m. This study showed how the Flex-Foot Cheetah can give its users more natural gait with competitive running power and speed (Buckley, 2000, p.354).

The most influential owner of the Flex-Foot Cheetah to date is South African Olympic runner, Oscar Pistorius. Pistorius uses two Flex-Foot Cheetahs and was able to produce sprinting times that qualified him into being the first Paralympian to compete in the Olympic Games. Because of Pistorius’ professional running technique, the
capabilities of the Flex-Foot Cheetah were maximized to Olympic competition quality. The Flex-Foot Cheetah can take athletes in need past walking to a competitive state of sprinting and enjoying sports.

**Ottobock Genium**

In most sports, the knee is a very important joint and allows the functions and actions necessary to participate at a high level. The knee is arguably the most intricate and complex joint in the body. The knee is also very vulnerable due to the stresses and pressure loads placed upon it. During the walk cycle, knees can support up to 1.5 times the weight of the body (Ethier, 2007, p.389). Therefore, if an athlete does not have the natural anatomical knee, it is critical that the prosthesis used be constructed with fine detail.

![Fig. 9. Ottobock Genium knee joint microprocessor controlled.](http://www.ottobockknees.com/knee-family/c-leg-microprocessor-prosthetic-knee/)
The Genium by Ottobock is a prosthetic knee joint that is controlled by a microprocessor. The Genium’s complex sensory system allows the patient’s gait to be mimicked to that of a natural gait. This prosthetic keeps a constant 4 degrees of flexion at all times during walking, to allow the Heel Strike phase to occur rapidly and put the foot on the ground more evenly. Genium has a gyroscope and a two-axis accelerometer which continuously sample the environment for the safest release and locking mechanisms (C-Leg, 2013).

During the Swing Phase of walking or running, the foot must clear the ground before Heel Strike in order to avoid stumbles and falls. In clinical study, the Genium has shown a maintained joint angle of 63.8 degrees of flexion at any speed of gait in order to avoid this problem (Bellman, 2012). The required flexion angle of the knee joint during Swing Phase in order to avoid stumbles and falls is between 60 and 65 degrees (Bellman, 2012). Therefore, the Genium knee is perfectly designed to keep users away from possible falls, due to poor walking mechanics.

![Fig. 10. Mean values of maximum knee flexion angles on the prosthetic](image-url)
The Ottobock Genium is a perfect knee replacement for athletes looking to seriously return or begin play. Athletes using Genium would be able to correctly pivot, accelerate, decelerate, and change directions safely, and correctly, due to its continuously functioning microprocessor and locking system. In another study of biomechanic function, “the Genium demonstrated immediate biomechanical advantages during various daily ambulatory activities, which may lead to an increase in range and diversity of activity of people with above-knee amputations” (Bellmann, 2012, p.541).

**Design**

Advances in computer science, biomedical engineering, and other technical fields continue to revolutionize athletics as well. The most effective injury prevention solutions, performance enhancement techniques, and mechanical assistance devices are useless if the information never reaches the athletes in need. Athletes need a means by which they can tap into a source for the cutting edge information. In a world driven by social media, a website for the latest developments in biomedical, genetic, and prosthetic studies applicable to athletics would be very beneficial. In theory, this website could then be transformed into a Facebook page, Twitter account, or any other social media database for circulating the usable information.

**Running the Program**

The program runs in Java, therefore Java must be installed on the user’s computer in order to run properly. To install Java:
1. Open Internet Browser and go to Java.com
2. Click on the free Java download selection
3. Select ‘Agree and Begin Download’ selection
4. When prompted select ‘Run’ to initiate download
5. When Java Setup window opens, select ‘Install’

After completely these steps, Java has been successfully installed on the computer and the program can be run by simply double-clicking the Jar file icon on the desktop, if the file has been saved to desktop. In the occurrence that the program does not run, the JRE needs to be installed and this can be completely by simply going back to Java.com for the free download.

**Java Swing**

This design is a very rudimentary prototype of the initial website idea in the form of a local program. The application programming interface (API) used for this design is Java Swing. Java Swing is an API that specializes in providing easy to manipulate graphical user interfaces (GPU) (The Java Tutorials, 2013).

**Main.java**

When a Java program is started, the “main” method is called. This beginning of my program is in the Main class. Here, a new MainFrame is created which builds the graphical user interface from the Swing API. This code creates a new JFrame which will display on the screen. A JFrame “constructs a new frame that is initially invisible” (Java Platform Standard Edition 7, 2013). The JFrame is basically its own window for the program to run in. Once a JFrame is created, a JPanel is added to it. The JPanel essentially holds the components (buttons, lists, text, ect.) that is displayed on the screen.
MainFrame.java

The next code file is the MainFrame.java file. Next the public class MainFrame extends JFrame. This creates a new MainView and adds the view to this JFrame. The MainView is the main JPanel that will hold all the components that make up the program. The MainFrame constructor will now be called whenever the “new MainFrame” is used. The JFrame is told to close when the ‘x’ button is clicked on the window by using the setDefaultCloseOperation. Because of the rudimentary style of the program, the JFrame will be the only window open and therefore the only necessary window to close to close the program.

From there, the MainView is constructed and is added to the JFrame’s Content Pane. The command pack( ) is a method provided in the JFrame class (Java Platform Standard Edition 7, 2013). Essentially this code tells the JFrame to make its size just big enough for the JFrame’s components to be displayed at each of their preferred sizes. A specific component can set its own preferred size when it is created. Lastly, setVisible(true) is written to display the JFrame and all components that fill it up.

MainView.java

The MainView has multiple components initially imported into it (JComboBox, JLabel, JPanel, JScrollPane, ect.). The MainView extends JPanel, similarly to MainFrame. In other words, it is a JPanel that has additional properties and components that I add. In MainFrame.java, I only added a MainView to the MainFrame (it extends JFrame), so this JPanel will fill up the window that is part of the MainFrame. Instance variables for the sidebar, work space, ‘sport’ combo box, ‘types’ combo box, and doc viewer are created to be implemented into those functions in the program. Integer
variables are created for the individual categories in the program (Overview, Baseball, Football, Track, Injury, Performance, and Mechanical) because they are constants that are used to coordinate with the indexes of each sport and enhancement type. Strings are created for the actual text names of the program categories as well as constants that are strings for each HTML file’s path in the program.

Then, the setLayout method is called. This will change the layout of the MainView to a BorderLayout. A BorderLayout is a type of LayoutManager (Java Platform Standard Edition 7, 2013). LayoutManagers instruct the JPanel where to put the component that is added (Java Platform Standard Edition 7, 2013). I’m using a BorderLayout because it can be used to make a component fill the remaining space of the JPanel it is applied to. In this case, the MainView is split into two sections: a “side bar” on the left, and a “work space” on the right. The side bar should only take up as much space as it asks for while the work space will take up the rest of the space. A simple add method is used to add the SideBar, WorkSpace, SportComboBox, TypeComboBox, and DocPane to the MainView. The side bar is a JPanel so that its components can be altered. Using setBackground and setPreferredSize, the side bar color is changed to a new color using the hexadecimal value of a specific color and the dimensions of the side bar are set respectively.

The work space is then added to the MainView and its components are altered using the same systematic approach as the side bar. Using JLabel and JComboBox, the ‘sport’ label is added to the MainView. A JLabel is a component that displays text (Java Platform Standard Edition 7, 2013). A JComboBox is a component that will show a list when clicked on and then when the user selects from the list, the original text will update
Next, an ItemListener is added to the JComboBox, where an ItemListener is an interface that has the method itemStateChanged (Java Platform Standard Edition 7, 2013). The JComboBox calls this method whenever an item is selected from its list. The ItemListener “listens” for this selection and signals the itemStateChanged method. Every time an item is selected, another item is deselected, and therefore, itemStateChanged is actually called twice. I only want the comboBoxItemSelected method to be called once, so I check if an item is selected and ignore when it is deselected using a simple if statement. The same systematic approach and modifications are taken for the other JComboBox in the program.

In this program, a document viewer is necessary, therefore I created the addDocPane method which creates a new JEditorPane. A JEditorPane is a component that takes in a file to display (Java Platform Standard Edition 7, 2013). In this program, I have a list of HTML files to display. The JEditorPane is kept form editing in the running program and the runtime error exception is thrown if a file is not found using two code sources from the Java code list (Java Platform Standard Edition 7, 2013). The JEditorPane is added to a JScrollPane. A JScrollPane is a component that takes in a single component and adds a scroll bar to it (Java Platform Standard Edition 7, 2013). This allows the JEditorPane to be larger than the screen since we can scroll to see the rest of it. The JEditorPane will be updated to display another HTML file whenever one of the JComboBoxes are selected. This is done by using the ItemListener that we added to the JComboBoxes. The file that is shown in the JEditorPane is determined by the newly
selected values from the JComboBoxes. Switch cases are used to create and return a new file from the path in the baseball, football, or track arrays. It is possible that the program looks to create a file and for whatever reason the URL is invalid. In this case, an exception will be thrown. Since a program crash is not desired, a try catch statement is used to intercept the exception and keep the program from crashing (Java Platform Standard Edition 7, 2013).

**Conclusion**

All in all, this local program made with Java Swing allows us to view different HTML documents. These documents are selected by the user interacting with the graphical user interface. The documents contain information about some of the latest advances biomedically, genetically, and mechanically that are applicable to athletes and the sports listed in the program. This rudimentary prototype is the beginnings of an information source for athletes to become knowledgeable about the advantages of technology in the athletic world.

**Program Code**

**Main.java**

```java
package com.russell.tech;

public class Main {

    /*
     * Starting point of the program.
     */
    public static void main(String[] args) {
        /*
         * Creates a new "JFrame" which will display on the screen.
         */
        new MainFrame();
    }
```
MainFrame.java

package com.russell.tech;

import javax.swing.JFrame;

/*
 * Creates a new MainView and adds the view to this JFrame.
 */
public class MainFrame extends JFrame {

    @Override
    public MainFrame() {
        /*
         * Tell the JFrame to close when the 'x' button is clicked on the window.
         */
        setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);

        // Construct the MainView
        MainView view = new MainView();

        // Add the MainView to this JFrame's Content Pane.
        getContentPane().add(view);

        /*
         * Determine the size of the JFrame.
         */
        pack();

        // Display the JFrame and all components that fill it up.
        setVisible(true);
    }
}

MainView.java

package com.russell.tech;

import java.awt.BorderLayout;
import java.awt.Color;
import java.awt.Dimension;
public class MainView extends JPanel {
    /*
     * Instance variables
     */
    private JPanel sideBar;
    private JPanel workSpace;
    private JComboBox sportComboBox;
    private JComboBox typesComboBox;
    private JEditorPane docViewer;

    /*
     * Constants that coordinate with the indexes of each sport
     * and enhancement type
     */
    public static final int SPORT_OVERVIEW = 0;
    public static final int SPORT_BASEBALL = 1;
    public static final int SPORT_FOOTBALL = 2;
    public static final int SPORT_TRACK = 3;
    public static final int TYPE_INJURY = 0;
    public static final int TYPE_PERFORMANCE = 1;
    public static final int TYPE_MECHANICAL = 2;
    private static final String[] sports = { "Overview", "Baseball", "Football", "Track and Field" };
    private static final String[] types = { "Injury", "Performance", "Mechanical" };

    /*
     * Constants that are strings for each file's path.
     */
    private static final String[] baseballFiles = {
        "/res/OttobockGenium/doc.html" };
    private static final String[] footballFiles = {
        "/res/BiodegradableSilkMatrixforAnteriorCruciateLigament/doc.html",
        "/res/PPAR/doc.html",
        "/res/OttobockGenium/doc.html" };
    private static final String[] trackFiles = {
        "/res/FrequencySpecificMicrocurrent/doc.html",
        "/res/ErythropoietinGeneTherapy.html",
        "/res/ssurFlex/doc.html" };
private static final String overviewFile = "/res/Overview.html";

/*
 * The MainView constructor.
 */
public MainView() {
    /*
     * Change the layout of the MainView to a BorderLayout.
     */
    setLayout(new BorderLayout());

    /*
     * Add components to the MainView.
     */
    addSideBar();
    addWorkSpace();
    addSportComboBox();
    addTypeComboBox();
    addDocPane();
}

/*
 * Adds the "side bar" JPanel to the MainView.
 */
private void addSideBar() {
    // Construct a JPanel for the side bar
    sideBar = new JPanel();

    /*
     * Change the background color of the side bar.
     */
    sideBar.setBackground(new Color(0xE5E5E5));

    /*
     * Set the side bar to request itself to be shown at a specific size.
     */
    sideBar.setPreferredSize(new Dimension(300, 900));

    /*
     * Add the side bar to the MainView. The second argument (BorderLayout.LINE_START) tells the MainView's LayoutManager that we set earlier, a BorderLayout, to add the side bar to the left side of the panel. It will allow the side bar to take up as much space as it requested (300 px x 900 px).
     */
    add(sideBar, BorderLayout.LINE_START);
}
private void addWorkSpace() {
    // Construct a JPanel for the work space
    workSpace = new JPanel();

    // Sets the layout just as I did before in the MainView constructor. The work space also
    // uses a BorderLayout so the document viewer component can be told to fill up all the space
    // available.
    workSpace.setLayout(new BorderLayout());
    workSpace.setBackground(new Color(0xFFFFFF));

    // Add the work space to the MainView. The second argument (BorderLayout.CENTER) tells the
    // MainView's LayoutManager to add the work space to the center of the panel. The
    // BorderLayout tells the center component to fill all remaining space.
    add(workSpace, BorderLayout.CENTER);
}

private void addSportComboBox() {
    JLabel label = new JLabel("Sport");
    sideBar.add(label);

    JComboBox sportComboBox = new JComboBox(sports);
    sideBar.add(sportComboBox);

    sportComboBox.addItemListener(new ItemListener() {
        @Override
    });
public void itemStateChanged(ItemEvent e) {
    if (e.getStateChange() == ItemEvent.SELECTED)
        comboBoxItemSelected();
}

private void addTypeComboBox() {
    JLabel label = new JLabel("Enhancement Type");
    sideBar.add(label);

    typesComboBox = new JComboBox<String>(types);
    sideBar.add(typesComboBox);

    typesComboBox.addItemListener(new ItemListener() {
        @Override
        public void itemStateChanged(ItemEvent e) {
            if (e.getStateChange() == ItemEvent.SELECTED)
                comboBoxItemSelected();
        }
    });

    try {
        /*
         * Same as the addSportComboBox except that the label is
         * "Enhancement Type".
         */
        docViewer = new JEditorPane();
        docViewer.setPage(loadFile(SPORT_OVERVIEW, TYPE_INJURY));
        docViewer.setEditable(false);
        // Tell the JEditorPane to not allow any editing in the view.
        docViewer.setEditable(false);
        // Catch the runtime exception that is thrown if a file is not found.
        catch (IOException e1) {
            e1.printStackTrace();
        }
    }
}
/* Create a JScrollPane and add the JEditorPane to it. */
JScrollPane p = new JScrollPane(docViewer);
workSpace.add(p, BorderLayout.CENTER);

/* This method is called whenever a JComboBox is selected. */
private void comboBoxItemSelected() {
  // Get the index of the selected item.
  int selectedSport = sportComboBox.getSelectedIndex();
  int selectedType = typesComboBox.getSelectedIndex();

  try {
    /*
     * Change the html file that is shown in the document viewer.
     */
    docViewer.setPage(loadFile(selectedSport, selectedType));
  } catch (IOException e) {
    e.printStackTrace();
  }
}

/* Loads the file appropriate file based on the sport and type. */
private URL loadFile(int sport, int type) {
  switch (sport) {
    case SPORT_BASEBALL: // if sport equals
      return getClass().getResource(baseballFiles[type]);
    case SPORT_FOOTBALL:
      return getClass().getResource(footballFiles[type]);
    case SPORT_TRACK:
      return getClass().getResource(trackFiles[type]);
  }

  return getClass().getResource(overviewFile);
}
References


Appendices

Appendix I

Upon opening the program, the ‘Start-Up page’ of the program with the ‘Overview’ document is viewable. The drop-down menus are located on the left of the ‘Information Display Window.’
Appendix II

The drop-down menu arrow for ‘Sport’ is selected and the selections are viewable and available for selection. Those include: ‘Overview,’ ‘Baseball,’ ‘Football,’ and ‘Track and Field.’
Appendix III

The ‘Baseball’ selection is selected and ‘Injury’ is held in the ‘Enhancement Type’ drop-down menu. The information for an innovative injury repair mechanism applicable to baseball is displayed.
Appendix IV

The ‘Enhancement Type’ drop-down menu arrow is selected and the selections are viewable and available for selection. Those include: ‘Injury,’ ‘Performance,’ and ‘Mechanical.’
The ‘Performance’ selection is selected within the ‘Baseball’ file. The information for an innovative performance enhancement mechanism applicable to baseball is displayed.
Appendix VI

The ‘Mechanical’ selection is selected within the ‘Baseball’ file. The information for an innovative prosthetic knee replacement device usable for baseball is displayed.
Within the ‘Mechanical’ page of the ‘Baseball’ file, the scrollbar on the right of the ‘Information Display Window’ is scrolled down and the rest of the page is displayed.