

Link to organization: <https://www.operf.org/rfas/smallgrant.aspx>

MEMORANDUM

To: Orthotic and Prosthetic Education and Research

From: David Lahoud

Date: 10/1/19

Subject: Research proposal letter of inquiry

Opening

Dear Research Committee Chair,

Thank you for taking the time to read this letter. I have always been interested in finding new ways to help people and one of the biggest questions I have had is how to best help people who use prosthetics. My answer to that is to try and research ways to improve upon current prosthetics. This is why I am reaching out to your company, as it is one that has done great work in helping provide funds for research and education on prosthetics and orthotics. In providing me funding, I will be able to advance research for prosthetics and will find ways to make current practices surrounding prosthetics more efficient along with making the prosthetics themselves more effective as replacement limbs. In the following sections I will be discussing the background for this research project, where it is now versus where it will go, and what benefits will be accrued from completing it.

Background

In the U.S. alone, according to statistics from the Amputee Coalition, there are nearly 2 million people with amputations. Also in the U.S., there are, each year, around 185,000 amputees that acquire prosthetics (Siek, 2012), showing there are many instances of people needing prosthetics. So far there have been advances in the field, as shown by Aimee Mullens breaking world records in three track and field events in the 1996 Paralympics (Siek, 2012). For this great achievement, it turns out she used prosthetic legs designed like cheetah legs rather than human legs. This shows how different thinking and ingenuity led to an advancement in prosthetic usage.

By researching prosthetics in terms of improvement instead of replacement, newer prosthetics could be made that would be more efficient limb replacements. It would also help people who need them, such as soldiers, rehabilitate back into society without feeling so different or inferior from everyone else in terms of looks and physical abilities. The purpose of my proposal is to try and advance research in this way so that more people can feel benefits rather than problems from prosthetics.

Proposal

The project I am proposing is to research newer and more efficient ways to create prosthetics. Using the results of the research, companies that develop these prosthetic limbs could implement and develop more efficient versions of current prosthetics, along with entirely new and unique ones. For this goal I am requesting \$25,000 from your institution for use towards research equipment, materials, and staff to help run experiments in order to test for the best versions of the prosthetics. After getting the project off the ground running, I will pull in more sources of funding in order to ensure that the project will be completed.

On top of creating better versions of prosthetics, I intend to research ways to reduce cost in the production of the limbs. The current average cost for a prosthetic can range from \$5,000 for the lower end products to \$50,000 for the higher end products (ABC News, 2013). There are different techniques employed currently to reduce the cost, such as using 3d printers to make the prosthetics. I would like to see about advancing those techniques and reduce the cost even further. By employing the newer researched techniques, manufacturing companies will be able to make and sell the prosthetic limbs at a much more affordable rate (Sreenivasan, N., Gutierrez, D. F. U., Bifulco, P., Cesarelli, M., Gunawardana, U., & Gargiulo, G. D., 2018).

Eventually I would love to advance this research project into researching the development of electronically enhanced body parts, allowing for the creation of what would be considered cyborgs. For this I would be researching ways to advance prosthetics in a way that doesn't just replace what has been lost but improves upon that loss. An example of this would be cybernetic eyes that have multiple functions for sight, such as night vision.

Conclusion

If you would be interested in learning more about this project and funding the research, please feel free to contact me at david.lahoud@unt.edu. I look forward to hearing back from you and I hope we get the chance to work together towards a better future for all people. I would love to answer any further question regarding this project in a full-length proposal. Thank you for your time.

Orthopedic and Prosthetic Education and Research Foundation

Prosthetic Research Advancement

Amount Requested: \$25,000

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Date: 10/20/1

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Abstract

This proposal asks for funding from the organization Orthopedic and Prosthetic Research and Education (OPERF) equaling \$25,000 in total. The reason for the funding is to afford the resources needed to improve the current research on specifically limb prosthetics. As explained further in the document, current limb prosthetic research has somewhat stagnated, mainly due to the lack of “outside the box” thinking that creates innovation. While advancements in making the process of creating prosthetics cheaper have been made, research and advancements into how to improve upon them has ultimately been a fruitless endeavor. Current scientists and researchers in this field are researching into ways to make prosthetics work more effectively as human replacement body parts. While this is not necessarily an incorrect way to go about this research, in order to actually make prosthetics something that people will feel are a quality replacement, a different style of thinking is required.

In my proposal I will be researching different materials and circuitry styles to make the prosthetics more durable along with having a more intellectual and human-like way of moving. On top of that, I will also be researching into different designs that would fit different situations that could prove more effective than the human limb design, such as how a cheetah’s legs are better designed to run than a human’s legs. I will need funding for research help and assistants, materials for testing, equipment to conduct tests and to build prosthetics, and other important parts that will be described later in the document. As with other research projects in this field, there will be some issues to address, such as ethical and societal acceptance issues. These issues are ones that are important to address in a way that ensures that people learn to accept and aren’t forced into a position. The way to handle the ethical issues, which would stem from designing prosthetics in animal form, would mainly come from people who see this as tampering with the human body. In response to that, I would quell the issues brought up by these people by explaining how the logic of the science is sound and how it isn’t messing with the body itself but providing a style of crutch that improves instead of hinders. There are other issues as I said earlier but I will address those in a section specifically designated for them.

This project has a timeline spanning a year to start, with possible extensions being required as some of the parts to this project require humans to be willing to try out the prosthetics in tests. The timeline for each grant activity involved in the project will be explained with the required time estimation further in the document. I hope that by the end of this narrative, you will see the importance of this research project along with how I am positioned best to carry it out and be willing to contact me for further information regarding the project.

Key Words: Human, Prosthetic, Ethical, Innovation

Introduction

Prosthetics have been in use as early as 3000 B.C., originating from East Circa. They have been used in many ways, being made from different materials such as wood and metal. These days, prosthetics tend to be made from lighter materials and be more effective, as we have evolved in technology since 3000 B.C. One of the first examples of a prosthetic in use is a wood and leather toe designed for an ancient Egyptian noblewoman, named “The Cario Toe” (Amputee Coalition, 2019). The literature compiled for this research goes more into the history of prosthetics and the different ones that have been made over time. The literature also supports the data and information covered in this paper and shows the means to understand where prosthetics currently are, along with where they will evolve. They set up the framework for understanding what needs to be understood to solve the problem posed with an optimal solution. They relate to the current project by giving information related to progressing the project, along with giving possible solution types that could be researched. The literature provides an idea of what the current issues are as well with this project specifically and show if ideas have already been done and researched, leading to the development of an idea to research that has not been researched yet, providing new insight and a possible solution to the problem.

Problem/Opportunity

This project is needed because of the amount of people who use prosthetics is tremendous. While this project focuses on limb prosthetics, the usage of that specific type of prosthetic, while low in comparison to elderly body replacement, is still incredibly large. In the U.S. in 2015, the number of people suffering from limb loss was estimated to be around 2,224,022 and the number of the users of prostheses being estimated at around 1,668,017 (Kelly, 2015). These numbers are only predicted to grow as time moves on and they only represent the U.S. There are many other places in the world that have amputees and prostheses users that would add to this number, making it a vital area to improve upon. An example of an area this would improve is the daily financial lives of the users of limb prosthetics. Current limb prosthetics cost a large sum of money to acquire, due to the manufacturing process and materials being expensive. By reducing the cost of what should be considered a basic necessity for people who need it, more people who could not afford this will now have access to it, and the people who could barely afford it will now be able to have less financial struggle.

Goal/Objectives

In similarity with OPERF's goals to help increase knowledge and education about prosthetics, along with finding ways to improve current prosthetics, the primary goal from this project is to create prosthetics from materials that will reduce the cost without reducing the quality, along with changing the circuitry, design, and production process in order to ensure a more effective prosthetic that will achieve these objectives. The people whose lives will be changed will be the ones who need to use prosthetics and either don't have the money to afford them, refuse to buy them because they seem like more of a hindrance than anything else, or if the prosthetics that the person is using are not effectively helping them in their day to day life. The ways that their lives will be changed is that they will be able to afford the prosthetics that they need, with the prosthetics being good enough that they will entice people to want and enjoy using them.

One of the primary parts that will be unique to this project is the idea of the design of the prosthetic. Instead of making a human designed prosthetic, designing the prosthetic to be similar to animal parts or be structured differently for different tasks is an important task in achieving the goal of making prosthetics more effective in usage. To fulfill these goals and objectives presented above, I am requesting \$25,000 as a starting point, along with room for applying for more funds from different organizations as well as yours. As a result of the research, prosthetics will become more effective in terms of manufacturing and usage.

Solution

In this research project, I will have a small group of research assistants along with me completing the research and recording the findings, results, and recommendations based on those results. We will complete the project by using different research methods along with different materials and circuit designs to create a more advanced prosthetic. I will be taking in ideas that seem out of the ordinary and try to implement them into actual products that we can then have users test to determine how effective they are in usage. Some of the equipment used in this project would be a 3D printer and microscopes for viewing circuitry, but other ways to create the prosthetics would be to involve a manufacturer and to have them work with me to create the prosthetics while being under contract. In order for the researchers and me to complete the project, I estimate that I will need around one full year with possible changes to the schedule that could increase the time it will take.

This is a process that will take some time to complete, though the benefits will be outstanding for the people who need these prosthetics to live a normal life. The people who need this are people who have had bad experiences in life, such as soldiers losing limbs in the line of duty, or even just a construction worker who happened to have a mistake with a saw blade. The way they will be affected is by having the ability to use limbs previously lost with precision, making it feel as though they had not lost that limb. This along with being able to afford the prosthetics due to the cost of production being reduced will be the primary ways these groups of people will be affected. The way that the prosthetics will look will be variable as the design is a more fluid option. This is because in this project, I will be using more unique designs that just human body designs to try and optimize the usage of the prosthetic while making sure that the prosthetic does not damage the body. Some versions of the prosthetics will have a human-like design while other versions of the prosthetic will have design that are more in line with animal body structures, befitting different purposes. There will possibly be more designs than this, depending on the creativity of the team, though as results are what I strive for in this project, it will be important for me to ensure that the design is usable in real life scenarios.

Over the rest of this proposal, I will be discussing the planning of the project and the steps toward enacting my solution. My steps will consist of methods and activities regarding the project, potential obstacles and ways to bypass those obstacles, and an evaluation that will serve as an assessment plan, showing how I will know once I have accomplished this goal. Other steps involved will be knowing the key personnel that will be involved with the project, and the timeline for the project to give an estimation of how long it will take along with progress markers. Finally, it will end with the results and significance of the project, the use of the requested money as a budget, and a narrative of the budget to help give greater detail regarding the usage of the money.

Transition to Project Plan

Your organization specializes in ensuring that these fields are researched and taught, thus making this project important to your cause, as it would improve current prosthetics along with making them cheaper, allowing more people to be able to learn about and use these improved prosthetics. In line with this, I believe that I am positioned best to carry out this project due to my experience and education in the field. I have a master's degree in Biomedical Engineering and have experience in robotics and prosthetics. I have completed projects involving the creation of prosthetic limbs, along with other projects that required me to have extensive knowledge on material science, circuitry, and engineering. I also have background in research methods and an understanding on how to conduct proper research to produce effective results. It is because of my background that I feel I will have a more effective time analyzing current prosthetics and researching ways to improve their design and effectiveness.

Method/Activities

In order to accomplish my goal of creating more effective limb prosthetics that are more affordable than current versions, I will need to complete some important tasks.

- The first task that I will need to complete is to study different designs, materials, and circuitry, along with different production processes. This is to see where the costs of making the prosthetics could be lowered while still increasing the quality of the product being made.
- Closely related, the next task is to ensure safety measurements are taken to ensure the comfort and safety of the user of the prosthetic. This is to ensure that the prosthetic will not cause adverse effects on a person's health and wellbeing, along with ensuring that extended usage does not harm the body.
- The next task is to compare different production processes and choose the process that best fits with the intention on how to create the prosthetics, along with setting up that process. This task is one of the more important ones, as it is necessary in order to even create the prosthetic to test.
- The next task is to then assess the quality of the prosthetics through small tests using both a human subject, for the prosthetics that don't have robotic logic in them, and with a remote for the prosthetics that do have robotic logic. These tests will need to be conducted in order to see progress on the prosthetics themselves while ensuring the safety of the user of the prosthetic.
- The following task is to record and analyze the results of the tests, apply the knowledge learned, and go through more iterations of the earlier tasks. This ensures that proper research is done and that improvement on the prosthetics is guaranteed.
- The final task is to record which version of the prosthetic was the most effective, complete a final report regarding its effectiveness, and discuss the setup for production and sales of the prosthetic.

Obstacles

The obstacles that I anticipate I will need to address are along with the ways I will address them are:

- The idea that prosthetic limbs will not look human can make some people uncomfortable as they might think it tampering with the human body.
 - The way I will address this is by explaining that I am not tampering with the human body but helping it become one with nature, as designs will typically stem from animals. I would also explain how prosthetics only help a person who has been disabled in some way, and that should not be a wrong thing to do. I will also show these people examples of the prosthetics in use, showing how useful and beneficial they are.

- The cost of the materials and manufacturing of the prosthetic.
 - In order to address this possible obstacle, an accurate and pinpoint usage of money will be used where looking for the cheapest price won't be the goal, but a byproduct of finding the quality material or manufacturer for that price. Another way to handle this obstacle is to take the other ways of manufacturing the prosthetics and try to implement them as different manufacturing processes have different costs.
- A lack of willing participants to help in testing the prosthetics.
 - In order to handle this possible obstacle, understanding how to complete these kinds of tests on products is essential. Ensuring that some kind of reward is given to the participant for their time is important in ensuring that there will be a steady flow of participants.
- Not enough funds to complete the project.
 - By applying and writing proposals to other organizations, I can ensure that the funds needed to complete the project can be secured, thus handling this obstacle.

Evaluation

In order to ascertain if I have accomplished the goal I have set for myself, a few qualifiers will need to be set.

- The first qualifier will be: is the finished prosthetic complete enough to use in real world applications? This is an important qualifier because even if the prosthetic fits every other qualifier, not being able to use in real world applications would essentially make it worthless.
- The next qualifier will be: is the prosthetic made of material that will reduce the cost to manufacture yet still provide high quality results? This paired with the next qualifier is very important due to the fact one of the main goals of this project is to decrease the cost of making the prosthetics in order to make them cheaper to sell and therefore easier to obtain.
- The following paired qualifier will be: is the manufacturing cost to make the prosthetic the best price it could be? The reason to have this qualifier is due to it being part of the main goal of this project.
- The next qualifier will be: does the electronics and circuitry in the prosthetics help make it more efficient in its usage, and is the design one that will have application in the real world? This is because making the prosthetics work more effectively is very important when improving upon prosthetics, and the different designs help prosthetics be more effective for specific tasks.
- The final qualifier is: has the prosthetic been made so that the prosthetic can be worn every day for lengthy periods of time without wear and tear on the body? This is because many people do not like wearing prosthetics due to the fact it hurts their body to wear them, thus fixing this problem would be a big part in improving prosthetics.

Personnel

In order to complete this project, I will need to have people fill certain key roles. Here is a list of those roles along with a small description of the role.

- Lab Assistants
 - The personnel filling this role will be essentially doing helpful work for everyone, not specific work on one task. They will be assisting all of the engineers in their work, helping find testers to test prototypes of the prosthetics, helping managing contact with any manufacturing company that gets partnered with, if one does, and overall helping with any other miscellaneous tasks. They will be key members of staff that will ensure that the personnel completing more specific tasks can do those tasks without interruption.
- Biomedical Engineers
 - The personnel filling this role will be creating the physical shells for the prosthetics, the neuron sensors, and other pieces that will go into the externals of the prosthetics. The main purpose of this role is to build the newer prosthetics and try to accomplish the goals of this project in the process. The biomedical engineers will use the lab staff for assistance and be in contact with the electrical engineers. This is to ensure that the electrical engineer's internal designs will work with the external designs for the prosthetic.
- Electrical Engineers
 - The personnel filling this role will be creating the circuitry and other internals of the prosthetic in order to ensure that the prosthetic actually works like it is supposed to. These engineers should strive to reach the goals of this project in order to make it a success. They will need to stay in contact with the biomedical engineers to ensure that the internal and external designs of the prosthetics will work together cohesively. They will also work with lab staff to ensure quality work is completed.

Timeline

The estimated timeline for this project will be:

- Beginning of the project:
 - Acquire the funds and proceed to hire the personnel for the project. This should only take up to two weeks as I will have been looking prior to the start date if my proposal gets accepted.
- After acquiring personnel:
 - Work with personnel to brainstorm ideas for new ways to reduce cost and increase efficiency, including materials, designs, and manufacturing processes. There will be multiple iterations of this step later on the project. This step should only take one day to complete.
- After the first round of designs has been completed and conceptualized:
 - The engineers and lab assistants will get started on working prototypes to fit the designs. The deadline will be two weeks after beginning the work. Close to the deadline, the lab staff will find people to test the prototypes.
- Once the first prototype is complete:
 - The users who will test the prototypes will try that round of prototypes while lab assistants and engineers take notes on the process. This should take around one week to ensure quality results.
- After completing this first round of testing:
 - The project will cycle through the earlier steps starting at the brainstorming step and proceeding down to the prototype testing step. The time taken for each step will be the same as before, unless unforeseen incidents occur that will cost time to fix. The amount of iterations that should be done to find a quality product will be around 25, giving an extra two weeks of wiggle room in case of incidents occurring.
- The final piece of the project:
 - The project will last around one year, and at the end, the final product will have been made to the best attempt and review to see if more time will be needed to complete the project will be done. After completing the review, a new timeline will be created for this project for every investor involved as there will be multiple funding sources I will have proposed to.

Results/Significance

Based on the results of this project, the intended result is to find ways to ensure that prosthetics are advanced, and the people who need them will have easier access to them along with wanting to use them. By making the cost of prosthetics lower while increasing the quality, more people will both want and afford the prosthetics. This will in turn lower the total amount of predicted people who are afflicted with limb loss that refuse to use prosthetics. The big significance of lowering that goal is that more people will be able to move back to how their lives were before the limb loss. This will also affect the people who were born without certain limbs by letting them live a better life by having the ability to have a limb they were not born with.

On top of just helping people in their day to day lives, this project will help make progress towards human advancement technology. While being a different type of project, human advancement technology will be beneficial in the long run, especially with technology such as exosuits becoming more popular. These types of technologies will replace current prosthetics in the long run; and shortening the time it takes to acquire usable and affordable versions is important. As this project only focuses on limb prosthetics, exosuits will not be researched, but it will help advance that research in the future.

Budget

For this project, due to there being other investing sources being involved, the primary usage of the funds from this research grant will be used in the following ways:

- Prosthetics shell materials such as, duralumin, copper, and other types of metals for manufacturers and plastics for the 3D printer. The cost for these materials will total to an amount of \$8,000.
- One 3D printer that is large enough to print the prosthetic shells with the cost of \$5,000.
- Parts for the internals of the prosthetic such as circuit boards and other bits of electronics that will be used. The cost for these materials will total to an amount of \$8,000.
- The rest of the money will be put towards acquiring the help of a manufacturer to produce the prosthetic for testing and usage. The range of the cost will be \$4,000.

Budget Table

Item	Cost	Purpose
Prosthetic Shell Materials	\$8000	Prosthetics shell materials such as, duralumin, copper, and other types of metals for manufacturers and plastics for the 3D printer
3D Printer	\$5000	One 3D printer that is large enough to print the prosthetic shells
Circuitry	\$8000	Parts for the internals of the prosthetic such as circuit boards and other bits of electronics that will be used
Manufacturers	\$4000	Acquiring the help of a manufacturer to produce the prosthetic for testing and usage

A more completed form of the budget will be submitted once research has been completed for which metals and plastics will be acquired, along with which electronic parts will be needed. The completed form of the budget cannot be done until this information has been acquired. The more completed budget will be submitted as a table with every item being explained, along with the exact price for each item. The other sources of funding will cover the salaries and costs of employees, facilities to complete the work, and other expenses that could appear as the project continues forward.

Closing Statement

In conclusion, I would greatly appreciate your organization considering me for this project for the improvement of limb prosthetics. I believe that I have to qualification and background knowledge to make this project a great success and I would love to be partner with you on this project and make a serious change to the way prosthetics are perceived and used. As said earlier, I will be submitting proposals to other organizations with the same goal in mind. This is to assure that the funds required for this project and acquired and not all of the funds are taken from your organization. On top of that, the timeline will be one year, so there will be a functional working model within one year, not including any unforeseen accidents. Thank you for taking the time to read this proposal and I look forward to hearing back from you.

References

- Siek, S. (2012, May 4). New prosthetic limbs 'celebrate' bodies, personalities instead of hiding lost limbs. Retrieved October 7, 2019, from <http://inamerica.blogs.cnn.com/2012/05/04/new-prosthetic-limbs-celebrate-bodies-personalities-instead-of-hiding-lost-limbs/>.

The author, Siek, goes into detail about prosthetics owners and how having differently designed prosthetics for different purposes is more effective than using one prosthetic for everything. Siek then pulls examples from real life where a person who needed prosthetics broke world records in the Paralympics using prosthetics designed like the hind legs of a cheetah. He then goes more into detail on her story and her thoughts regarding the idea of using prosthetics designed in more unique ways that fit different situations.

- Kahle, J. T., & Highsmith, M. J. (2011, July 30). Practical Strategies for Reducing Prosthetic Costs. Retrieved from <https://www.amputee-coalition.org/resources/reducing-prosthetic-costs/>.

The authors, Kahle and Highsmith go into detail about different strategies on reducing prosthetic costs that are implementable now. It goes over the current process of acquiring a prosthetic from the user side, along with how expensive it can be and how to reduce those expenses. Ways that the article uses to reduce costs could be, for example, getting a fitting for the prosthesis as a definite prosthesis as that can save 15 – 30 percent in the first two fittings. There are other examples of where to cut costs in the current process getting a prosthetic that are explained in detail.

- Gillian Mohny. (2013, April 25). The Cost of a New Limb Can Add up Over a Lifetime. Retrieved from https://www.hss.edu/newsroom_prosthetic-leg-cost-over-lifetime.asp.

The author, Gillian Mohny, goes into detail about the costs of prosthetics and how they add up initially and over time. Mohny goes into the initial costs of acquiring a prosthetic along the amount of time till the prosthetic gets worn out from wear and tear. He then explains how prosthetics are fitted to the specific person using them, and how the price can also vary based on the components you can choose to either add or not add. On top of the cost of the prosthetic, it will take time in physical therapy, also adding a cost, and after a year will most likely need a second prosthesis to fit their changing body, restarting the process again.

- Frost & Sullivan (2018). 3-D Printing to Lower Prosthetic Costs. Retrieved from <https://aabme.asme.org/posts/3-d-printing-to-lower-prosthetic-costs>.

The authors, Frost and Sullivan, go into detail about the expensive nature of prosthetics at the moment, and a way to reduce the cost of production. They explain how 3D printing could essentially create most of the prosthetic while still allowing for high quality products that work efficiently. They also explain how the computer aided design (CAD) could improve the process of manufacturing prosthetics by reducing the cost and having the ability to be more precise, making higher quality prosthetics at a lower cost.

- Sreenivasan, N., Gutierrez, D. F. U., Bifulco, P., Cesarelli, M., Gunawardana, U., & Gargiulo, G. D. (2018). Towards Ultra Low-Cost Myoactivated Prostheses. *BioMed Research International*, 2018, 1–14. doi: 10.1155/2018/9634184

The authors of this research article go into detail about how myoactiated prostheses will reduce the cost of prosthetics by a large amount. These myoactivated prostheses will reduce cost by being easy to maintain, manufacture, and do not require elctrodes in contact with skin to work correctly. The rest of the paper goes into the example created, which is a small and functional hand prosthetic, and how the myoactivated prostheses is made.

- Tong, Y., Kucukdeger, E., Halper, J., Cesewski, E., Karakozoff, E., Haring, A. P., Johnson, B. N. (2019). Low-cost sensor-integrated 3D-printed personalized prosthetic hands for children with amniotic band syndrome: A case study in sensing pressure distribution on an anatomical human-machine interface (AHMI) using 3D-printed conformal electrode arrays. *Plos One*, 14(3). doi: 10.1371/journal.pone.0214120

The authors of this article go into detail about the usage of prosthetics that have low-cost sensors and are formed using 3D printed manufacturing methods to reduce the cost. The prosthetic experiment was completed making these prostheses for children suffering from the common birth defect amniotic band syndrome. The article goes into how effective the process and prostheses were in helping the children with this birth defect, along with how they went about making the prostheses.

- “History of The Prosthetic Leg Through The Ages.” *Amputee Coalition*, Amputee Coalition, 19 Apr. 2019, <https://www.amputee-coalition.org/history-prosthetic-leg/>.

The author of this article goes into detail about the history of prosthetics and their usage through time. The author explains how prosthetics started as early as ancient Egypt, with the first recorded prosthetic being a wooden toe. The author then continues to the middle ages and onward, all the way to the 19th century, explaining the usage of prosthetics in those time periods. On top of going over the history of the prosthetics themselves, the author goes into the people who were important in advancing the science of prostheses from each era.

- Kelly, Kevin. "Prosthetic Limbs Forecast to 2050." *Kk Lifestream*, Extrapolations, 8 Oct. 2015, <https://kk.org/extrapolations/prosthetic-limbs-forecast-to-2050/>.

The author, Kevin Kelly, goes into detail about prosthetics usage data and how there is a predicted increase in people who will need prosthetics by 2050. The author uses data and statics to show how the increase in usage will be exponential and will continue to increase, however, the amount of people who will use prosthetics vs the people who need them but will not use them will be lower. This is how the author emphasizes that prosthetics need to be more accessible, cheaper, and more comfortable to use, otherwise most people will choose to not use them due to it not fitting in with their lifestyle.