A Study/Meta-Analysis of Human Augmentation Using Robotic Technology in Medicine

Dylan V. Karig '21

I find that a really good way to begin a paper such as this is to give a fundamental understanding of what human augmentation encompasses. From my collective research, the concept of human augmentation is the field of research aiming to enhance the human ability through medicine and/or technology. This definition seems to be a commonality amongst scientists, as mentioned in Roope Raisamo and company's paper concerning this field (Raisamo et.al, 2019). According to Jonathan Shimoda, an active mechanical engineer with an extensive background in human augmentation, there are three levels of human augmentation: replication, supplementation, and exceeding human ability (2019). These terms seem to be of his own creation, for I have not seen other articles that categorize human augmentation into levels (especially in such a fashion), but I do feel as if these terms are a rather acceptable way of classification. "Replication" (according to Shimoda) consists of the usage of augmentation to re-create an ability that most humans (without disorders/abnormalities) have: it is a simple re-creation of a human trait/pre-existing function (Shimoda, 2019). "Supplementation" is similar to the concept of replication but taken a step further; "supplementation" enhances and betters the human ability (Shimoda, 2019). "Exceeding" is human augmentation that goes far and beyond what the human body can actually do (Shimoda, 2019). All three levels of augmentation are potentially involved in medicine, but the level that will be most focused on throughout the duration of this paper is the "replication" level. This is because a majority of the current uses of human augmentation in medicine is for the purpose of replicating a typical human action that has been lost in the individual patient. This paper will focus on the origins of augmentation, current uses, hopeful future advances, and a meta-analysis of an extraordinary case of human augmentation.

Origins of Human Augmentation: One of the first examples of human augmentation is plastic surgery (Stern, 2013). After World War I, soldiers would return home with massive disfigurements on their faces, whether it was losing an ear, a nose, or skin from burns (Stern, 2013). Based on my previous definition of augmentation, one may question my inclusion of plastic surgery as a beginning of augmentation, for this does not seem like a form of "technology". This would be an appropriate time to set a definition of "technology": the *Cambridge Dictionary* defines technology as "the methods for using scientific discoveries for practical purposes, esp. in industry". Following this understanding of technology, I am identifying plastic surgery as a form of technology used for augmentation. This, obviously, was not a robotic technology, but it feels important to note the beginnings of human augmentation and the basis of what it was used for.

Robotic, or more technologically advanced, limbs are way more common to be used as a prosthetic than anything else. It is estimated that around thirty million people globally need a prosthetic limb, but only about a quarter of that estimated number actually have one (Burt, 2018). Prosthetics actually became known originally in the B.C.E times, and the first documented case of a prosthetic was an artificial big toe on an Egyptian woman who needed the toe to be able to wear a traditional Egyptian sandal (Bell, 2015). Technological advances have come a long way since this time, but it was only until the last decade that tremendous strides in robotic prosthetics. Using myoelectric signaling, David Gow (of Scotland) was able to create the first robotic hand prosthetic in 2013 with the ability to open and close all five fingers using cognition (BBC, 2015). Electrical signals sent from the brain to a motor device at the base of the prosthetic conduct the action of moving each finger in a particular direction (BBC, 2015). The past decade has shown plenty of augmentation advances, including bionic feet, fingers, hands, ear implants for auditory ability, and noses for facial reconstructive surgery (Bell, 2015).

Current Uses and Implementation

Human augmentation as we know it today blows the past out of the water. The availability and vastness of what has been achieved is to a degree even mind-boggling to comprehend: the strides that have been made

are in their own right extraordinary. One of the biggest current focuses of human augmentation in medicine is to create not just the replication of the human ability, but to also create a limb that is physically appealing and aesthetically pleasing to the human eye (Bell, 2015). The addition of 3D printing technologies and the usage of carbon fiber has made prosthetics both easier to create and lighter and more comfortable for patients (Bell,2015).

Image 1: *This is an image of the "Bartlett Tendon", a revolutionary sports knee designed by Brian Bartlett. The prosthetic knee was carefully designed to not only serve the basic function of a prosthetic, but to provide comfort and sleekness to what used to be a rather uncomfortable prosthetic.*

UNYQ is one of many companies that specializes in creating artificial prosthetic covers using 3D printing technology (Bell, 2015). This in itself can show the current shift in prosthetics from a more practical usage to now wanting to make everything as comfortable as possible for the patient: there has been a more recent focus on also helping the mental confidence of the patient along with physically helping them be able to function again.

Another current shift in focus is the aforementioned idea of using cognition to be able to control these bionic ligaments. Research at schools across the globe is being dedicated to such a thing; colleges have teams of researchers working tirelessly to develop this software. David Gow's bionic hand was the catalyst for a wide array of advancements, including bionic feet that respond via cognition, artificial ears that can send auditory signals to the brain to be processed, and other technological advances like LASIK (Stern, 2013).

Future Applications:

The future of human augmentation has extreme cap to become something that cannot even be fathomed as of now. Technological advances, over the past few years in particular, have been exponential, and projections for the future look rather intriguing to say the least. One such example is an exoskeleton that gives the individual wearing it extraordinary strength and abilities. Another example comes from Raisamo and colleagues, in which they predicted that the future of human augmentation will lean in the direction of the creation of "enhancement of the senses" technology (2019). These technologies will be aimed to aid the elderly in an attempt to make the retirement age increase by about ten years (Raisamo et.al, 2019). There is also, based on a multitude of studies conducted by Raisamo and colleagues, research being conducted in hopes to create these new technological advancements to be more natural (2019). This is being done due to the expression from augmentation recipients exclaiming the anxieties and stresses associated with having a ligament, particularly the anxiety that comes from the fear of people staring.

Some rather interesting advancements, as listed by Jonathan Shimoda, are being postulated for the future. An invisibility cloak, for example, is an idea that was once only fathomed in sci-fi movies. Even now that idea does not seem to be imaginable, but there are strides being made for this to be something of a possibility in the future. Various researchers are already able to cloak objects and surfaces, and strides are being made to apply this technology to a human cloaking device (Shimoda, 2019). Artificial blood cells are, as of right now, theoretical, but research is being done to recreate whale or dolphin red blood cells (Shimoda, 2019). This is due to the fact that it is believed that whale and dolphin red blood cells can hold more oxygen. Nanobots are another creation that are hopeful for the near future. These devices would be used to enter the human body and potentially fight diseases and cancers growing within the body (Shimoda,2019). Synthetic memory chips are being researched into, where they could potentially serve the brain

as a perfect memory device. These chips would be inserted into the brain of humans and would help keep a perfect memory and have the individual never forget anything.

Meta-analysis: Hugh Herr:

*All of the information from this section and meta-analysis came from a Discover Magazine section discussing the story of Hugh Herr, an amputee who has an extraordinary story, as well as an article from Hugh herr discussing the importance of robotics for human augmentation. They will both be included in the references of this article.

Herr, at seventeen years old, was an avid climber who constantly was taking his adventures to new extremes. He decided to go on a trip during the winter to ice hike and climb with his best friend Jeff Batzer. They were climbing New Hampshire's Mount Washington, and a severe and harsh winter storm came in, blinding and disorienting both of them. They were found three days later by a woman who happened to be walking, and both of them suffered severe frostbite and needed amputations. Herr's friend Jeff lost toes and his thumb, but Herr lost both of his legs and needed prosthetics. Upon realizing that his prosthetics were not the least bit comfy, he knew something needed to change. He started experimenting with artificial limbs at a local machine shop. Where he began designing ideas for comfier prosthetics. He designed a prosthetic that was lighter, smaller footed to make the ability to walk easier, and adjusted the height of them to enable himself to be able to reach higher peaks while climbing. He continued climbing and eventually ended up becoming an inductee into the national sports hall of fame for his climbing.

Hugh Herr was able to graduate with a master's degree in mechanical engineering from MIT and a Ph.D. in biophysics from Harvard. Using this newfound knowledge, Hugh Herr was able to start up a company called iwalk, aiming to create prosthetics that provide the best comfort and ability for people who need them. Herr designed the PowerFoot One, the world's first robotic ankle-foot prosthesis, in 2008. This Powerfoot One has an electric motor, a quarter-size inertial measurement device that aids with adjusting and tracking location. This prosthetic was leaps ahead of its time. Herr also designed for himself a set of bionic limbs that adjust about five-hundred times a second for optimal comfort and location help. Hugh Herr is extremely hopeful to continue his research and seems to be elated at the idea of human augmentation. He agrees with every other researcher that has the passion to continue advancement of prosthetics and augmentation that eventually there will be a mash-up of human and robot. He believes that this will lead to the dismantling of disability and anyone with them will not have to worry about suffering any symptoms of them. Herr's motivation also comes from his admiration for those in the armed services who have themselves lost limbs. All in all, Hugh Herr's story is one that feels out of a movie, and definitely feels worthy of a tribute in a paper like this.

Concluding Statement(s)

The idea of human augmentation was once one of imagination only possible in Sci-Fi movies, but the strides made by researchers in the past few decades have been nothing short of amazing. From an artificial big toe in the B.C.E era to artificial limbs that have motors and use myoelectric signals and cognition, the timeline of events with human augmentation has been nothing short of amazing. It seems all the more mesmerizing that these technological robotic advancements can be used to impact the lives of individuals that really need the aid, providing a form of solace for these people afflicted by such conditions and disabilities. Human augmentation in medicine has provided opportunities to turn what would have once been a debilitating, devastating disability into a mere obstacle on the road of life for the individuals afflicted, and the future of augmentation looks bright.

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