

The Role of Positivity:  
Physical and Mental Aspects of Lower Limb Amputation Due to Diabetes

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HN 300: Honors Capstone

December 10, 2018

## Introduction

It is estimated that the number of people afflicted with diabetes will rise from 171 million people worldwide in 2000 to 366 million people worldwide in 2030<sup>1</sup>. Diabetes causes an increased risk of heart disease and infections, high blood pressure, kidney disease and many other bodily malfunctions. This disease can even result in a plethora of other diseases thus causing a domino effect of health concerns. A common ailment that those with diabetes face is peripheral artery disease which leads to neurological damage in peripheral limbs. This condition commonly results in the amputation of the lower limbs. As a result of this serious procedure, patients may become withdrawn and discouraged, but it is important for them to stay optimistic throughout the recovery process. Mental health ties in greatly with the physical health and progress of patients. It is important to keep a healthy mindset throughout the entire amputation and rehabilitation processes.

Diabetes is a disease that can be acquired due to life choices, type II diabetes, or it can be diagnosed due to one's lack of bodily functions, type I diabetes. Both forms of diabetes occur when there is an issue with the hormone insulin made by the pancreas. Insulin is a hormone which assists glucose in reaching cells to be used as energy. When glucose does not reach the cells, it remains in the blood which causes high blood sugar and not enough energy for one's cells to function efficiently. Type II diabetes occurs when one's body does not use insulin properly and thus causes blood sugar to be too high. The risk of developing type II diabetes increases due to genetics, such as race, age, and family history as well as lifestyle choices such as eating, physical activity, and weight. People who suffer from depression are also more likely to develop diabetes<sup>2</sup>. Meanwhile, when afflicted with type I diabetes, the body simply does not make insulin because the patient's body attacks the cells in the pancreas that make insulin. Type I diabetes is usually diagnosed in children but can appear at any age. The risk of developing type

I diabetes is not increased due to life choices as type II diabetes. It is imperative that those afflicted with diabetes take precautions and manage their diabetes according to their physician<sup>2</sup>.

### Diabetes Implications

Diabetes has a high prevalence of comorbidities if not taken care of properly. Since both type I and type II diabetes affect the entire body, it is important to manage and take care of the entire body. Priorities for patients with diabetes includes testing their blood glucose level over three month periods, monitoring blood pressure along with cholesterol, and ceasing smoking if applicable<sup>3</sup>. A major complication for patients with type II diabetes is the development of foot ulcers. A problem that coincides with foot ulcers is the development of peripheral artery disease in which the risk of development increases with diabetes<sup>4</sup>. Peripheral artery disease (PAD) is when the arteries to the lower limbs are narrowed, hence reducing blood flow to the limbs. PAD results in many painful issues including leg numbness, painful cramping in muscles, and most concerning, sores on toes, feet, and legs that will not heal<sup>5</sup>. Furthermore, diabetes can result in diabetic neuropathy which, according to research by Tesfaye and Boulton<sup>6</sup>, effects 50% of people with type II diabetes. Diabetic neuropathy is nerve damage that can result in different parts of the body in patients with diabetes. This nerve damage is common in areas such as the feet, lower limbs, and heart<sup>7</sup>.

Many of the diabetic implications that will be addressed cause either short term or chronic pain. Pain can sometimes be debilitating and is very often associated with limitations to daily functions of life. Pain often produces a negative affective response in individuals causing feelings of agitation, anxiety, and anger<sup>8</sup>. This is most likely attributed to the body alerting one's self to escape from the situation that is causing pain. However, the issue with chronic pain is that one cannot escape it and instead continues to feel the pain which can further stir negative emotions. However, a recent literature review from Finan and Garland<sup>8</sup> addresses the possibility

of pain modulation through a positive affect. In this review, positive affect is defined to be feelings or emotions that produce a sense of relaxation, serenity, and contentment. Although the level of pain that was felt varied, the majority of studies analyzed in this review saw that when patients had an increased level of positive affect, the level of the pain they were feeling was reduced. Presence of a positive disposition has demonstrated to lessen the perception of pain as well as lessen negative thinking, while absence of positivity has been shown to expose patients to negative pain outcomes. Based off this evidence, it is important to keep a positive affect when faced with pain and throughout all the implications that patients with diabetes can possibly face.

Patients with diabetes who develop foot ulcers or even a small scratch or wound on the foot are at an increased risk for lower limb amputation. If patients suffer from peripheral artery disease, blood flow is restricted to the limbs due to the constriction of arteries, which are responsible for bringing blood from the heart to the limbs. PAD affects 27 million people in the United States alone<sup>4</sup>. Without blood flow and nutrients brought to ulcers or wounds, wounds are unable to heal. Since oxygen molecules are delivered to muscles via blood cells, there is a mismatch in the actual oxygen supply and the oxygen demand from the muscles. As the disease progresses, the nutritional supply to the muscles is incapable of happening. As a result, lower limb tissues begin to degenerate which can ultimately lead to amputation. According to research by Chaudhary, et al.<sup>4</sup> the natural course of PAD is limb loss in one third of patients with a six month mortality rate of 20%.

Diabetic neuropathy and peripheral artery disease alike are leading causes of disability in the United States. The most common form of diabetic neuropathy is peripheral diabetic neuropathy which effects the limbs. Diabetic peripheral neuropathy (DPN) is the presence of peripheral nerve dysfunction in people with diabetes<sup>6</sup>. Often times, DPN is the major contributor

to foot ulcers as well as amputation. According to a meta-analysis by Dam and colleagues<sup>9</sup>, the degeneration of nerves is of a multifactorial etiology, but is vastly due to the compromised nerve vascular supply which is interrelated to PAD. Vascular changes occur earlier on in the diagnosis of diabetes and often lead to nerve damage. Nerve damage occurs with an increase of anterior-venous shunting, which is when blood does not innervate to smaller spaces, but instead passes directly from arteries right to veins. This causes a bypass of nutrients to the outer layer of the nerve and ultimately results in nerve death. DN destroys proper nerve function, especially in peripheral limbs, which greatly effects foot ulcers. It is important for patients who suffer from DN to check their feet for ulcers or wounds often since DN prevents proper proprioception, pain reception, as feedback.

When managing diabetes patients can often feel overwhelmed and discouraged due to the many comorbidities. However, even when faced with the struggle of managing diabetes, it is important to stay positive. This is because one's outlook on their situation influences how they react to situations, as well as how others react to you<sup>10</sup>. Often times, positive thoughts will lead to positive results. Patients who suffer from diabetes cannot get caught up in the big picture of all the negatives that can happen, but instead must give themselves credit for small achievements. By succeeding in small goals, such as having better blood glucose control one day, patients are more likely to adhere to managing their diabetes. Patients must highlight the positives in things, such as exercising for 15 minutes instead of not reaching 30 minutes of exercise<sup>10</sup>. This positive outlook helps one continue other self-driven positive behaviors.

However, due to the increased likelihood of foot ulcers combined with the issue of developing complications of nerve damage and poor blood circulation for patients with diabetes, there is a tremendous increase in the likelihood for amputation. According to research conducted

by Gregg et al.<sup>11</sup>, 73,067 adults with diabetes underwent a lower limb amputation in 2010. More than 80% of amputations begin with foot ulcers due to the severe damage caused to tissues and bone<sup>12</sup>. Signs that foot ulcers may potentially lead to amputation are discolored skin, foul odor, an ulcer that lasts longer than one to two weeks, an ulcer bigger than two centimeters, and/or an ulcer so deep that bone is exposed. If the ulcer results in a condition where there is severe loss of tissue or life threatening infection, amputation may be the only option. When undergoing an amputation, the surgeon will remove damaged tissue and preserve as much healthy tissue as possible. Once the amputation procedure is completed, the patient will stay in the hospital for multiple days to be monitored. The patient will then start rehabilitation and the wound will take four to six weeks to heal. Following the surgery, it is important to follow the treatment plan outlined by the primary care physician as well as the surgeon. Patients who undergo one amputation are at an increased risk of having another amputation<sup>12</sup>. It is necessary to eat healthy food, control blood sugar levels, avoid tobacco, and exercise regularly in order to prevent additional diabetes complications.

### Amputation Further Implications

However, often times lower limb amputation leads to infection. In a ten year retrospective study conducted by Dutronc and colleagues<sup>13</sup>, out of 72 patients who underwent major lower limb amputation, 44% required surgical revision in addition to antibiotic treatment due to infection. In over half the amputee patients, over half were diagnosed with a stump infection within six weeks of initial surgery. Patients who suffered from bone infection were more likely to require further amputation than patients who has a soft tissue infection. The most frequent bacterial infection associated with lower limb amputation in diabetic patients is staphylococcus. Often times this bacterium is resistant to antibiotics in a phenomenon called methicillin resistant staphylococcus aureus (MRSA). Grimble and colleagues<sup>14</sup> conducted a

study which showed 21% of patients undergoing amputation were MRSA positive which increased the mortality rate of that group. Patients who had MRSA were less likely to achieve primary healing of the stump and also experienced delay healing due to chronic infection, meaning patients with MRSA had higher rates of morbidity and mortality. It is important that if amputees show signs of infection, they are tested for MRSA before starting treatments on antibiotics to prevent further infection and the risk of mortality. It was estimated that the three year survival rate in patients with major amputation, above or below the knee, was 24.1% while the survival rate in patients with minor amputations, toes or metatarsals, was 93.0%<sup>15</sup>.

Further implication after undergoing limb amputation is the possibility of developing phantom limb pain. Phantom limb pain (PLP) occurs in 60 to 80% of patients after undergoing limb amputation<sup>16</sup> and its underlying mechanisms are not fully understood. Phantom limb pain is often characterized by electric shock sensation, cramping, throbbing, and stabbing pain in the limb that was amputated and is no longer there<sup>17</sup>. After World War II, over 14,000 United States soldiers lost a limb during combat, many of which experienced phantom limb pain. However, during this time, phantom limb pain was seen to be a psychological issue, so many victims of PLP did not share their pain due to fear of being seen as mentally ill<sup>17</sup>. Although not fully understood today, there are many theories as to how phantom limb pain surfaces after suffering a limb loss. According to a meta-analysis conducted by Collins, et al.<sup>17</sup>, the most common central nervous system theory of PLP is the cortical remapping theory. After amputation, the brain responds to the limb loss by reorganizing its somatosensory map which is responsible for sensations such as touch, pressure, and pain. Following the amputation, the patient's cortical, central motor, and sensory networks are intact but sensory input has been reduced, resulting in a perceptive mismatch between central expectancy and peripheral feedback. The peripheral body is

intact, but the somatosensory input is altered, thus causing a mismatch of information. This mismatch is then enhanced by the lack of visual feedback from the missing limb which generates excessive pain despite the lack of sensory stimulus. The phantom limb pain can then be worsened if the patient has dreams where the missing limb is present. This is due to the fact that the somatosensory experience creates altered reactions with the mental and physical body. Furthermore, studies conducted with adult monkeys<sup>18</sup> following amputation have shown that neurons once used for the amputated limb will connect with a new body area since they are no longer needed in the original area. Thus, there is evidence that demonstrates the reorganization of cortical brain maps in the somatosensory cortex following amputation. Additionally, proprioceptive memory further contributes to the mismatch between brain remapping and bodily image. Proprioception is one's awareness to body positioning in space. Although missing the limb, amputees will still have the memory of the missing limb due to the body's proprioceptive memory that serves to complete tasks more efficiently. However, the role of the somatosensory cortex in PLP is debated due to research that there are no relationships between cortical remapping and PLP with arguments that many factors, such as the peripheral to central and central to peripheral pathways, maintain the same pathway and cortical representation which causes PLP<sup>17</sup>. The etiology of phantom limb pain is much debated and further extensive research may unlock answers to support certain theories

Since the cause of PLP is up for debate, it makes it more difficult to find treatments to relieve PLP. From a pharmacological standpoint, drugs such as gabapentin, pregabalin, and antiseizure medication is used to reduce PLP<sup>17</sup>. From a therapeutic point of view, mirror therapy is one of the most low cost and effective treatments<sup>19</sup>. When undergoing mirror therapy, a patient attempts to relieve PLP by positioning a mirror in front of the intact limb in order to serve as a

visual representation for the missing limb. This creates a visual feedback for the brain in order to reduce pain. This treatment theory has also been tested using virtual reality goggles in order to provide visual feedback by stimulating the existing and missing limb. Often times, but not always, patients receive relief from PLP.

Other than exclusively biological and neurological implications, phantom limb pain may cause a plethora of psychological effects on the patient. Phantom limb pain can cause patients to suffer from emotional fatigue, stress, cognitive distress, and negative body perception<sup>20</sup>. The largest comorbidities associated with phantom limb pain are emotional factors. These emotional factors include anxiety and depression which have a high prevalence in many chronic pain cases, and especially phantom limb pain. The 12 month prevalence of anxiety disorder in individuals with phantom limb pain was 33% higher in men and 37% higher in women versus those amputees without phantom limb pain<sup>20</sup>. Patients who suffered from phantom limb pain were three times more likely to develop depression than those who reported no phantom limb pain. Furthermore, mood disorders were also more prevalent in patients who suffered from phantom limb pain. However, phantom limb pain can be maintained based upon how patients react to it. A study by Parkes<sup>21</sup> found that individuals who suffered from persistent PLP often times scored higher on personality measures of rigidity. It was proposed that those with inflexible personalities resisted change and experienced chronic PLP because of their inability to adapt to the inevitable consequences of amputation. Thus, patients who are able to control their mindset over amputation are less likely to suffer from associated PLP. It is important to adapt to the situation and take obstacles in stride to avoid additional pain. Furthermore, stress plays a key role in the development and maintenance of chronic pain in general<sup>22</sup>. Stress serves as a trigger to phantom limb pain episodes. It is of utmost importance for amputation patients to not only cope

with stress in a positive manner, but to avoid stress where possible to mitigate pain. Once again, keeping a positive mindset will foster a reduced stress environment.

### Amputation Rehabilitation

Following amputation, it is important for patients to begin rehabilitation in order to regain independence, develop functional mobility, and improve quality of life. Although there is no real consensus on exactly what intensity, frequency, and type of rehabilitation is needed following amputation, a systematic review by Ulger and colleagues<sup>23</sup> shows vast similarities in rehabilitation programs. This review analyzed nine studies in order to evaluate prosthesis application, rehabilitation, and physiotherapy in lower limb amputees. After amputation surgery, it is important to get fitted with the appropriate prostheses as soon as possible. Prostheses depend upon age, cause of amputation, number of extremities involved in amputation, accompanying complications, and level and side of amputation<sup>23</sup>. Being fit with the prosthetic is one of the first steps to rehabilitation to eventually function normally with the prosthetic. Patients who receive their first prosthetic describe their fitting as a “sense of turning the corner”.<sup>24</sup> This is often an exciting time in a patient’s rehabilitation process because it gives the patient a sense of hope that they will soon be able to go on walks with their spouse again or play catch with their child. Getting fit with a prosthetic often inspires positivity in patients and inspires them to create goals for rehabilitation. It is important to get fit with a prosthetic early to remain positive about the future rehabilitation process. Furthermore, it is important to stay positive when first getting fit with a prosthetic. Underlying the excitement of the prosthetic fitting is often nervousness and worry that the process will be too difficult. However, patients must remain positive in order to aide in the rehabilitation process. Positivity will keep patients motivated to attend sessions which will increase their mobility and in turn, increase their daily life functions.

Rehabilitation with amputation is outlined as the interventions that aide in patient's familiarity with their prostheses, overcoming complications of using the prostheses, and enabling patients to return to daily life activities. In past years, the focus of prosthetic rehabilitation has been mainly on independent walking with the prosthetic. Although this is still an important focus, more recent studies have additionally focused on strengthening exercises, gait training, video games, weight-bearing exercises, coordination exercises, and functional activities of daily life. The aim of this literature review was to examine recent technological and scientific progress in regard to rehabilitation of amputees in order to determine the best approach.

### Psychosocial Effects of Amputation

Amputation is not only a physical battle but is also a mental battle. The most common psychosocial challenges faced by amputees are depression, anxiety, body image concern, and social discomfort<sup>25</sup>. In a literature review conducted by Horgan and MacLachlan<sup>25</sup>, depression is most common in the period shortly after amputation and has been listed as the primary reason why patients report decreased use of their prosthesis during rehabilitation. Depression was also associated with activity restriction, feelings of vulnerability, and poorer self-rated health. Overall, most patients who undergo amputation are likely to experience depression in the first two years of amputation and rehabilitation. However, after the first two years rates of depression in amputees decrease to what is found in the normal population. Anxiety has a similar trend<sup>25</sup> to depression. A significant number of patients, 53%, experience anxiety within the one year post amputation period, however these levels decrease to normal population values after the first two years following amputation.

Effectuated body image is another psychosocial consequence from amputation. Body image is defined as feelings and attitude towards one's own body as well as an individual's psychological experiences which are influenced by environmental and personal factors<sup>25</sup>. This

form of anxiety is associated with low levels of self-esteem, high levels of general anxiety, poor perceived quality of life, and higher rates of depression. Social functioning is affected by amputations as well. After undergoing an amputation, amputees acknowledge the fact that they look ‘different’ from the general population<sup>25</sup>. Often times, amputees are seen as disabled and are often seen as members of a stigmatized group<sup>26</sup>. This stigma results in different reactions by non-disabled people because assumptions are often made on the individual who is disabled. People may assume that the disability is the core aspect of the amputee’s identity, or that the amputation was a negative occurrence that the individual suffered. Common reactions from non-disabled are ignoring the disabled for fear of saying the wrong thing or being extremely kind to amputees since they view them as “disadvantaged”. In large, a group of amputees was given greater social distance by a group of students than a group of non-disabled individuals<sup>25</sup>. Furthermore, amputees found difficulty in participating in social activities as well as increased social isolation. Two-thirds of amputees were less likely to go to dances, shows, sports events, cinema, and theatre due to their disability and their insecurity of their appearance and fear of being judged<sup>25</sup>. Both social discomfort and decrease in social function can be largely due to depression. However, it has been shown that patients who go to events and surround themselves with a positive social and emotional support system have an increased quality of life compared to those without a support system<sup>27</sup>. A factor effecting psychological adjustment to amputation is the cause of amputation. Often times, amputees with vascular related amputations are more likely to show hostility and anger following amputation than amputees who suffered from a traumatic injury, who usually experience denial<sup>25</sup>.

### Mental and Physical Health Intertwined

Since prosthetic rehabilitation is not only physically demanding, but psychologically demanded as well<sup>23</sup>, it is pivotal to keep a positive mindset throughout the process. As discussed,

both depression and anxiety are normal and justified reactions to the loss of a limb. However, having an optimistic attitude and positive mindset going into an amputation can have positive results. Often times, when patients undergo amputation due to vascular disease or illness, the amputation procedure serves as relief from pain and is a solution to the constant suffering of pain coming to an end<sup>25</sup>. After initial amputation, it is possible for patients to feel mutilated and vulnerable after surgery. At this time, it is very important to have positive coping strategies. A negative coping strategy amputees often experience is catastrophizing which is when the patient imagines situations to only get worse than it actually is<sup>25</sup>. Catastrophizing is associated with increased depression as well as increased pain intensity. This negative coping strategy sets patients back both mentally and physically. Positive coping strategies will ultimately result in the patient's final view of themselves regarding body image. Furthermore, positive meaning after amputation is related to lower levels of depression. This is due to the fact that a positive disposition results in higher level of perceived control as well as a higher level of self esteem<sup>25</sup>.

A positive mindset is not only associated with statistics about decreased depression, but it is also recommended by actual patients. In a study conducted by Young and Resnick<sup>28</sup>, 62 hip fracture patients were asked the key functional recovery components that had a positive effect on their rehabilitation. Although these were not amputees, both amputations and hip fractures cause significant mortality, morbidity, and disability implications that patients must overcome for better quality of life. The key factors that participants identified in a functional recovery program were a positive attitude and self-determination. Patients stressed mental attitude and the importance to have the mindset to "never give up" to help functional recovery status. A high level of perceived self-efficacy was a significant factor based upon the fact that self-efficacy is a person's belief that their personal actions will bring desired change. Participants were asked to

give peer advice for others going through the rehabilitation process in which they suggested for patients to maintain positive and avoid worry. Positivity is not only important from a patient standpoint, but it is important for rehabilitation providers to demonstrate positivity. Participants in the study noted that professionals had a major impact on their recovery, and that a positive attitude by the professional provider was important to the patients<sup>28</sup>.

Furthermore, determination was a key factor to a successful rehabilitation program. Patients highlighted the importance of self-determination and their own personal desire to recover<sup>28</sup>. In a rehabilitation setting, therapists and aides will help assist in the rehabilitation and to achieve goals outlined on initial evaluation. However, health care professionals are unable to control the amount of effort that is put into rehabilitation settings by their patients. It is up to the patient to have to want to get better and want to accomplish goals that help return life functions to pre-amputation status using the prosthesis. If patients do not show up to therapy sessions, or give minimal effort, then less than desired results will occur. Another important factor that coincides with determination is resilience. Patients must be able to overcome adversity during rehabilitation and not give up hope when facing difficult tasks. In the study by Young and Resnick<sup>28</sup>, research actually unveiled that patients who demonstrated resilience were able to form adaptive behaviors especially regarding social functioning and confidence.

When it comes to the health field, positivity seems to be the “cure all” or the placebo effect to every ailment. However, positivity and determination are rarely the deciding factor in life or death. Being positive will not shrink a malignant tumor or even do so much as cure a common cold. Of course, positivity will help one to have a better outlook on life and perhaps give patients a reason to persist in the face of adversity, but it will not rid them of imminent death. Along the same lines, rehabilitation does not determine life or death. Patients can live a

basic life without rehabilitation. Their life would be dependent upon others and not as highly functioning as it was prior, but they would still be alive. During the rehabilitation process positivity is not a needed lifeline, but it is a factor that can drastically affect advanced rehabilitation. Without positivity and determination, there would be no reason to show up to therapy sessions. This is often seen with patients who skip or cancel many appointments and never learn correct use of their prosthetic device. Instead, these patients become reliant on wheelchairs and on others to function. On the other end of the spectrum, there are patients who attend therapy multiple times a week, who keep a positive attitude, and who are determined to return to normal life functions pre-amputation. These patients who reap the benefit of physical therapy are also the patients who will reap the life rewards. This is due to the fact that physical therapy increases the mobility of patients. Patients who attend physical therapy are able to complete more tasks and to be mobile in order to function as close to how they did before amputation. For this reason, increased mobility is strongly associated with increased quality of life<sup>29</sup>.

### Conclusion

Diabetes is a common disease which if not properly treated can have a long lasting, life altering effect. It is not only important to prevent further diseases from developing, but it is also pivotal to keep a healthy mindset while afflicted with the disease. A healthy mindset can mitigate pain perception, reduce anxiety and depression, and be a key determinant in rehabilitation to return to daily functions. Although amputations may produce a life altering effect on a patient, the patient can learn to adapt to his or her new image and new prosthetic. In order to best return to daily life functions, patients must keep a positive attitude and be determined to get better. Furthermore, it would be of great value to patients if positivity training was a part of the rehabilitation process. If patients went through this mental training in addition to their physical

rehabilitation, they would acquire useful skills to use to progress their rehabilitation. They could learn about the power of positivity, and how it has been proven to decrease pain, decrease depression and anxiety, and improve quality of life.

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