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Hudson, Lucas W.

Examining the Relationship Between Balance Confidence and the Physical and Psychosocial Adaptation to Transtibial Amputation on Physical Activity Participation and Avoidance Habits

by

Lucas W. Hudson

Supervisors: Dr. Taryn Klarner and Dr. Paolo Sanzo

Committee: Dr. Carlos Zerpa

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Abstract

Introduction: Transtibial amputation (TTA) is the removal of the lower leg at the tibia and often results in pain, mental health issues, and reduced quality of life. Many of these symptoms are created or exacerbated by a sedentary lifestyle, and a lack of physical activity (PA). Less than 40% of people with TTA participate in PA. It has been speculated that people with TTA who have low balance confidence may actively avoid PA to avoid falling and the associated pain that comes with it. This relationship has been detected in people with lower extremity amputation where they avoid stressors in general, but not in an exclusively TTA population or in the context of PA. Alternatively, other factors related to the physical and psychosocial adaptation to amputation such as depression, anxiety, or impaired mobility may be responsible for the avoidance of PA in people with TTA. The exercise avoidance patterns of people living with TTA has received little research. As such, the purpose of this study was to explore the relationship between balance confidence and the physical and psychosocial effects of TTA and how this related to PA participation and avoidance habits.

Method: Twenty-one participants with TTA (14 male, 6 female, and 1 non-binary) were recruited. Participants completed an online survey consisting of the Activities-Specific Balance Confidence Scale that measures balance confidence, the Trinity Amputation Prostheses Experiences Scale that measures the physical and psychosocial adjustment to TTA, the Baecke Questionnaire that measures PA participation, and the Tampa Scale for Kinesiophobia that measures PA avoidance. Spearman and Pearson correlations, based on normality distributions, were performed to determine the relationships between these variables.

Results: There was a significant positive relationship with a moderate effect size (r_s=.48) between balance confidence and the sport index scale (p=.03). Correlations with the physical and psychosocial effects of adaptation to TTA revealed multiple significant correlations with both PA participation and PA avoidance.

Conclusion: TTA is a complex and life changing event and adaptation to this event is an ongoing process. Those who participate in sport following TTA seem to show an association with social adjustment and balance confidence. Adaptations such as adjusting to the new limitations and activity restrictions of amputation, as well as satisfaction with the function of the prosthetic limb, are all related to PA participation and avoidance habits. These associations seem to highlight possible factors to better understand the PA participation habits of TTA for future research. Regardless of the causality of these relationships, participating in PA, specifically sport has physical and psychosocial benefits that cannot be undervalued. Healthcare practitioners should design rehabilitation programs for people with TTA that focus on balance confidence training and facilitate a positive physical and psychosocial adaptation following TTA.

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List of Abbreviations

ABC- Activities-specific Balance Confidence Questionnaire

BAQ- Baecke Physical Activity Questionnaire

cm- Centimeter

ICC- Intraclass Correlation

LEA- Lower extremity amputation

PA- Physical activity

PAD- Peripheral artery disease

QoL- Quality of Life

TAPES- Trinity Amputation and Protheses Experiences Scale

TSK- Tampa Scale of Kinesiophobia

TTA- Transtibial amputation

Chapter One: Introduction

Transtibial amputation (TTA) results in physical changes that include loss of the lower leg at the level of the tibia. In turn, TTA causes changes in proprioception around the amputated limb, decreased strength, reduced muscle mass, functional mobility changes, alterations in the temporal and spatial aspects of walking, increased energy expenditure, and force production deficits in the residual limb while walking (Adams & Lakra, 2020; Bolger et al., 2014; Hewson et al., 2020; Kavounoudias et al., 2005). Of all the prescriptions, treatments, therapies, and modalities researchers have developed to improve physical and mental health, one of the most beneficial things people with TTA can do is simply participate in physical activity (PA) (Ekelund et al., 2020; Langford et al., 2018).

The trauma of experiencing amputation is not limited to physical effects; many psychosocial effects and adaptations are also common following TTA. These effects can include decreased perceived balance confidence, increased risk of depression and anxiety, body image issues, and the trauma of TTA can exacerbate previous occurrences of depression and anxiety (Horgan & Maclachlan, 2004). These effects can be extremely difficult to overcome. Physical activity can improve mental health and overall recovery and quality of life. If individuals were not physically active or had poor mental health prior to the event this can make it more difficult to engage in a behavioural change to include PA in to one's daily life. These changes are not easy to make and may require support from health care providers or counsellors, yet they are critical because presently, the two-year mortality rate for all people living with TTA is 30% (Dormandy et al., 1999).

When PA is performed in appropriate doses, it has been shown to help people living with TTA prevent, reduce, and mitigate many of the negative effects, both physical and psychosocial, that occur as a result of the amputation (Hewson et al., 2020). Physical activity has been defined by the World Health Organization as any movement produced by the muscles that requires energy expenditure (World Health Organization, 2020). Physical activity includes active transportation like walking or biking, actively working out or playing sports, or any other activity that requires movement and an elevated heart rate (Caspersen et al., 1985). The physical benefits of participating in PA include improved balance, increased lower limb strength and muscle mass, and functional mobility improvements (Esposito et al., 2017; Gailey et al., 1994; Nolan, 2009; Vrieling et al., 2009). Physical activity has also been shown to have psychosocial benefits in people with TTA including the reduction of anxiety and depression symptoms and improved body image and balance confidence (Dinas et al., 2011; Horgan & Maclachlan, 2004; Mandel et al., 2016).

Despite these documented benefits, only 32% of people living with TTA participate in PA outside of their activities of daily living (Kars et al., 2009). In addition to this, when these people do participate in PA, they rarely reach the minimum daily recommended doses of PA (Langford et al., 2018). The minimum daily recommended dose of PA is 150-300 minutes of moderate intensity PA each week. This standard was set by the Australian Physical Activity and Sedentary Behavior Guidelines. The Canadian national recommendation is similar, recommending 150 minutes of moderate to vigorous intensity PA each week (Ross et al., 2020). Previous research has shown a positive relationship between higher PA levels in people with TTA and higher levels of balance confidence (Mandel et al., 2016; Miller et al., 2001). Individuals with higher balance confidence however, also have a greater risk of falling when compared to their less confident peers (Wong et al., 2015). Mandel et al. (2016) speculated that people with TTA who have low balance confidence may actively avoid PA, to avoid potential falls, and avoid pain. This relationship has yet to be substantiated with empirical evidence. It is also possible that other factors related to the psychosocial adaptations to amputation, such as depression, anxiety, or body image issues, are responsible for the avoidance of PA in people living with TTA.

Generally, exercise avoidance patterns of people living with TTA have received little research. The following literature review explores the etiology and epidemiology of TTA, the physical and psychosocial adaptations that occur after TTA, and the benefits of PA for these physical and psychosocial adaptations. This review also highlights the relationships between TTA and PA that warrant further examination and understanding.

The purpose of this study was to explore the relationship between balance confidence and the physical and psychosocial effects of TTA and how this related to PA participation and avoidance habits. Insights drawn from this study can be used by healthcare practitioners when developing rehabilitation plans for people with TTA. Ensuring that the outcome measures used by rehabilitation programs, such as balance confidence and physical and psychosocial adaptation to TTA, are appropriately related to the desired outcomes of the rehabilitation program, such as increased PA participation and decreased PA avoidance, is essential in ensuring the effectiveness of a rehabilitation plan and optimizing the process of adaptation to TTA.

Chapter Two: Background Information on Transtibial Amputation

Transtibial amputation is the most common form of major amputation in the world. In general, amputations affect approximately 1.7 million people in the United States. Upper extremity amputation comprises approximately 41,000, or 3%, of these amputations. The remaining 97% of amputations occur in the lower extremity (Braza & Martin, 2020). Transtibial amputation comprises 55% of all major lower extremity amputations (Imam et al., 2017). Lower extremity amputation (LEA) refers to any amputation of the lower limb, whether that amputation is of the distal phalanx of the fifth digit or the whole foot, shank, or leg. To help healthcare practitioners distinguish between the severity of amputations, LEA has been classified into major and minor amputation categories. Major amputation is defined as any lower extremity amputation occurring above the ankle. Amputation occurring at or below the ankle, although traumatic, is considered a minor amputation (Imam et al., 2017). Major LEA is further classified into three main groups: transfemoral amputation, knee disarticulation amputation, and TTA (Imam et al., 2017). Transfemoral amputation, often called above the knee amputation, is performed by bisecting the femur and removing the distal end of the leg. Knee disarticulation amputation occurs at the knee joint, disarticulating the ligaments of the tibia from those of the femur and patella to remove the distal end of the leg. Transtibial amputation, also known as below the knee amputation, is performed by bisecting the tibia and fibula and removing the distal end of the leg (Adams & Lakra, 2020; Albino et al., 2014; M. Myers & Chauvin, 2020).

In the following sections the etiology as well as epidemiology of TTA will be reviewed. This assessment will be followed by a review on the physical adaptations that people experience following TTA. This review includes changes in gait, balance and functional mobility. Finally, the psychosocial adaptations to TTA will reviewed. Specifically examining balance confidence and other psychosocial factors of depression, anxiety, and body image. This chapter will conclude with the purpose and specific research questions of the present study.

Etiology of Transtibial Amputation

Multiple conditions brought on by various etiologies can require an individual to undergo TTA. In Canada, the most common conditions requiring amputation are diabetes-related complications such as peripheral artery disease (PAD; 65.4%), followed by non-diabetic PAD and infection (25.6%), trauma (6.0%), cancer (1.8%), and congenital defects (0.6%; Imam et al., 2017). In the following sections, etiologies of amputation from PAD, diabetes, trauma, cancer, and congenital defects are reviewed.

Peripheral Artery Disease. The vast majority of amputations (diabetic and non-diabetic) are the result of PAD (Levin et al., 2020). Peripheral artery disease refers to atherosclerosis, or plaque buildup, in the arteries of the lower limbs. These plaque buildups narrow the arteries, restricting blood flow and increasing blood pressure. Over time, chronic restriction of blood flow and increased blood pressure results in reduced oxygenation and nutrition to the tissues of the lower limb. Peripheral artery disease creates a litany of potential complications including hypertension, cardiovascular disease, and kidney disease. When amputation is a consideration, PAD has progressed to its end stages. At this time, the patient develops symptoms that include ischemic rest pain, non-healing ulcers, and gangrene (Levin et al., 2020). Ischemic rest pain presents as a burning pain in the distal end of the lower limb. Ischemic rest pain is caused by hypoxia and acidosis, both of which are caused by poor blood circulation in the area (Levin et al., 2020). Peripheral artery disease is associated with multiple functional outcomes including reduced lower limb strength and endurance, slower walking velocity, and an impaired quality of life (QoL; Morris et al., 2014). Physical activity is considered essential in the prevention and treatment of cardiovascular diseases such as PAD (Whayne, 2011).

Amputation caused by infection is also directly related to PAD, as non-healing ulcers are a common symptom of late-stage PAD (Thiruvoipati et al., 2015). Typically, these wounds occur as the result of a self-inflicted trauma. Self-inflicted trauma has a variety of causes including unnoticed trauma to the foot (like stubbing a toe or stepping on glass) or friction between the foot and poorly fitting footwear (Watkins, 2003). Initially, the trauma can appear inconsequential, but due to ischemia and neuropathy the wound refuses to heal. Ischemia prevents wound healing by restricting blood flow and depriving the wounded area of the oxygen and nutrients required for cell healing. Neuropathy prevents wound healing by disabling the lower limb's ability to protect itself. When non-healing ulcers occur on the plantar aspect of the foot or other points of constant friction (such as the digits or the heel), neuropathy can prevent the potential amputee from feeling the painful sensations that would prevent an average individual from continuing to irritate the wound. Constant irritation of this open wound can quickly cause long lasting damage to the area (Levin et al., 2020). With both limb ischemia and non-healing ulcers present, gangrene can quickly develop. Gangrene is identified as black or discolored tissue and is caused by a lack of oxygen to the area (Buttolph & Sapra, 2021). Treatment of gangrene involves the removal of the dead tissue, revascularization of the dead tissue and, sometimes, amputation. Surgeons do their best to amputate at the lowest level possible; however, excessive necrosis of the foot often requires major amputation. Even when caught early, removing gangrenous tissue can drastically impact QoL and mobility (Buttolph & Sapra, 2021; Haji Zaine et al., 2016). If the signs of limb ischemia (ischemic rest pain, non-healing ulcers, or gangrene) persist for more than two weeks, the patient is considered to have critical limb ischemia. Critical limb ischemia, when left untreated, will continue progressing until amputation is required. Observational studies have found that 30-50% of patients living with critical limb ischemia will require major LEA within the next year (Levin et al., 2020).

Diabetic Amputation. Diabetics require amputation for many of the same reasons non-diabetics do, however, PAD is twice as common in diabetics as compared to the general population (Thiruvoipati et al., 2015). Little is known about PAD specific to diabetic populations versus PAD in non-diabetic populations. The same PAD symptoms apply to both diabetic and non-diabetic populations. Diabetes compounds with PAD as it creates a hyperglycemic, dyslipidemic, and insulin resistant state within the body. This insulin resistant state is associated with vascular inflammation, derangement of cellular vasculature, and worse health outcomes (American Diabetes Association, 2003). This state exacerbates and accelerates the long term outcomes of PAD, represented in the 2.6 times higher rate of diabetic amputations compared to non-diabetics with PAD (Imam et al., 2017). The relationship between PAD and diabetes is reciprocal, with 20-30% of patients with PAD having diabetes and 30% of diabetics having PAD. It is likely that the number of diabetics with PAD is actually underrepresented as many diabetics are symptomatic and they simply cannot feel these symptoms as a result of the presence of diabetic neuropathy (Thiruvoipati et al., 2015).

Traumatic Amputation. Unlike diabetic- and PAD-related amputations, traumatic amputations are not directly related to these comorbidities. Traumatic amputation is typically caused by a high impact injury that separates, or requires separation, of the limb from the rest of the body such as a motor vehicle accident, farming incident, or mishap with power tools (Jorge, 2020). Even when traumatic injuries only result in partial amputation (or just a severe injury), amputation may be required if the remaining limb is too damaged to be salvaged or if the damaged area becomes infected, gangrenous and necrotic (Buttolph & Sapra, 2021; Tintle et al., 2010). Transtibial amputation is the most common type of amputation performed on trauma patients (Tintle et al., 2010).

Lifestyle factors such as occupation, age, and gender are the most common predictors of traumatic amputation with young male adults experiencing traumatic amputation at the highest rates (Tintle et al., 2010). Although amputations caused by trauma typically result in better physical outcome measures, the trauma of the incident that necessitated the amputation in the first place cannot be understated. People with traumatic amputations never get the opportunity to make lifestyle changes to prevent amputation, nor are they given time to come to peace with it. In fact, the first time most people with a traumatic amputation even consider amputation is when they are awake and limbless in a hospital bed (Tintle et al., 2010). While traumatic amputation is every bit as traumatic as the name implies, people with traumatic amputations are typically younger and healthier than people with other etiologies of amputation. This typically results in a higher baseline activity level as well as better long term physical outcomes when compared to other amputation etiologies (McCarthy et al., 2003).

Cancerous Amputation. Occurring in only 1.8% of LEAs in Canada, cancer as an etiology for amputation is rare (Imam et al., 2017). Osteosarcoma and Ewing Sarcoma are the most common forms of cancer requiring amputation. Both of these cancers are typically pediatric, occurring in 6% of cancer cases when patients are under 20 years of age (Varma et al., 2014). Fortunately, cancer related amputations are uncommon, and the rate of amputation dropped 4.7% annually from 1988-1996 due to improvements in treatment and prevention. Lower extremity amputations, transtibial and transfemoral, account for 36% of all cancer related amputations (Dillingham et al., 2002).

Congenital Amputation. Congenital amputation, also termed congenital limb deficiency, occurs when a child is born with a deficiency in their extremity such as over- or undergrowth of the limb, missing digits, extra digits, or failure of the digits to separate (Boyd, 2020). The cause of congenital amputation is unknown but genetic variations, environmental teratogens, and gene-environment interactions are all thought to be factors (Ephraim et al., 2003). Congenital amputation is the rarest form of amputation occurring in only 0.6% of Canadian LEAs (Imam et al., 2017). Beyond this, upper extremity congenital deficiencies are two to three times more common than lower extremity deficiencies (Ephraim et al., 2003).

Epidemiology of Transtibial Amputation

Regardless of the cause of the amputation, TTA is the most prevalent form of LEA in Canada, occurring in 55% of all major LEAs (Imam et al., 2017). This means the majority of Canadian LEAs have completely lost their ankle joint but have had no major mechanical or functional changes to the knee joint (Karmarkar et al., 2014). In contrast, people living with a transfemoral amputation no longer have a natural knee joint (some transfemoral prosthetics utilize a prosthetic knee joint), and those living with a knee disarticulation amputation have had the function of their knee joint severely altered depending on the specifics of their amputation. Healthy populations have fully functional ankle and knee joints. Thus, people with TTA present with unique physical changes and abilities from other amputee populations and from healthy populations. When comparing unilateral and bilateral amputation, people with bilateral TTA have been shown to experience more severe physical and psychosocial effects following amputation when compared to unilateral (Akarsu et al., 2013).

Unfortunately, 15% of people with TTA undergo transfemoral amputation in the two years after amputation; another 15% will have a major contralateral amputation; and another

30% will be dead (Dormandy & Vig, 1999). When compared to people with transfemoral amputation, people living with TTA are two to three times more likely to achieve full mobility, require less energy to ambulate, and have overall better psychosocial outcomes (Hewson et al., 2020; Horgan & Maclachlan, 2004). As such, TTA represents a critical junction that, for many, must coincide with an accompanying lifestyle change as the majority of TTAs are directly related to a lack of PA and a sedentary lifestyle. In order to prevent further disease development, and to improve both the physical and mental health of people living with TTA, it is critical that people living with TTA participate in PA. Failing to do so will result in further impaired mobility, potential additional amputations, and much worse psychosocial outcomes.

Amputation rates vary wildly from country to country. Countries, like Italy, have reported LEA rates as low as 5.1 amputations per 100,000 people. Other countries, like Germany, have been reported to experience LEA amputation rates as high as 31 amputations per 100,000 people (Moxey et al., 2011). This difference in amputation rates likely indicates a difference in demographics of the people living with LEA in these countries such as ethnicity or socioeconomic status. It is also possible there is a different standard of care between countries affecting the number of amputations performed.

When examining sex/gender differences and amputation, men experience traumatic amputation at a higher rate than women with a risk ratio of 4.94. Men also experience PAD related amputation at a higher rate than women with a risk ratio of 1.75 (Dillingham et al., 2002). When women do experience LEA, they have been reported to have significantly worse prothesis related outcomes, mental health, and a lower rate of employment compared to men (Cimino et al., 2021). Cimino et al. (2021) proposed that the worse mental health outcomes reported by women may be related to body image. It is common for people with an amputation to experience body image distortion as they have just experienced a major life change. People who have body image distortion are more likely to experience anxiety and depression, and they also have a lower Quality of Life (QoL) and poorer self-esteem (Horgan & Maclachlan, 2004). Themes regarding challenges with body image are more commonly reported by women (Stutts et al., 2015) but it should also be mentioned that women are chronically underrepresented in LEA research and this may affect the reported findings (Cimino et al., 2021).

Adaptation to Transtibial Amputation

Adaptation to the anatomical changes created by TTA is both a physical and a psychosocial process. The physical effects of amputation include reduced muscle strength in the lower limb and impaired proprioception around the amputation. This results in a range of functional deficits such as slower walking speeds, increased energy expenditure, and both temporal and spatial gait deviations (Gailey et al., 1994; Highsmith et al., 2016; Schmalz et al., 2002). Although the physical effects of TTA are significant, they must not be considered alone as adaptation to the psychosocial effects of TTA has actually been considered more difficult than adaptation to the physical effects (Randolph et al., 2014). The psychosocial elements can include higher levels of depression and anxiety, body image issues, and pain. Unfortunately, the traditional biomedical model of disease examines the mind and body separately, as if the two exist independently of each other. This approach prevents optimal management of many conditions such as obesity, PAD, and TTA as the physical effects of these conditions are frequently accompanied by difficulties adapting to the psychosocial elements. These psychosocial effects can manifest as physical symptoms such as increased pain levels and depression, thus leading to higher levels of disability (Landers et al., 2016). These psychosocial effects are not considered alongside the direct physical symptoms of the disease when using the traditional biomedical model (Gatchel et al., 2007).

In 1977, the biopsychosocial model was conceptualized by George Engel. This model examines suffering by incorporating the biological factors of a condition with the psychological and social factors. By incorporating these three factors, the biopsychosocial model can examine both the disease and the illness. The disease is the anatomical, pathological, or physiological disruption occurring within the body, the physical effects being experienced, or the biological factors. The illness is the subjective experience of disease and how that disease is perceived by the individual (Engel, 1977; Gatchel et al., 2007). The biopsychosocial model has broadened the scope of healthcare practitioners to include more holistic health-related factors to better address the needs of their patients; furthermore, it allows researchers to acknowledge the interconnectedness of the physical, psychological, and social effects stemming from the anatomical effects of TTA (Borrell-Carrió et al., 2004).

Physical Adaptation to Transtibial Amputation

The physical effects of amputation include reduced muscle strength in the lower limb, altered interlimb symmetry, and impaired proprioception around the amputation. This results in a range of functional deficits such as slower walking speeds, increased energy expenditure, and both temporal and spatial gait deviations (Gailey et al., 1994; Highsmith et al., 2016; Schmalz et al., 2002).

Strength. Strength has been defined as “the ability to produce force against an external resistance” (Suchomel et al., 2018 p. 766). Low muscular strength has been associated with multiple negative outcomes including greater need for assistance with the tasks of daily living, increased chronic disease, and physical disability (Volaklis et al., 2015). In contrast, high levels of strength have been associated with reduced rates of depression, injury, and chronic disease prevention (Volaklis et al., 2019). Following TTA, lower limb strength largely depends on the etiology of amputation. Amputation related to PAD often results in weakness in the muscles of the lower limb compared to healthy populations. Asymmetry between the limbs is also common in PAD-related amputations, where the residual limb is often weaker than the intact limb. People with an amputation that was not related to PAD presented with lower limb strength greater than those with PAD-related amputation (Hewson et al., 2020). Lower limb strength can even reach normal levels or higher in physically active groups (Nolan, 2009). Even when amputation was not related to PAD, people with TTA who live a sedentary lifestyle still presented with greater hip muscle weakness and asymmetry than those who were recreationally active (Bäcklund et al., 1968; Nolan, 2009). Overall, the current state of the literature underscores the need to examine participation in and avoidance of PA, especially in sedentary populations. Non-sedentary populations are important to study as well, helping researchers and healthcare practitioners learn which psychosocial traits may be linked to both participation and avoidance of PA.

Asymmetry. Bilateral asymmetry between the lower limbs is commonly found when comparing the residual and intact limb of people living with TTA. Asymmetry refers to the balance, or lack thereof, between muscle groups. The terms asymmetry and symmetry are used interchangeably throughout the literature (Bishop et al., 2017). For clarity, strength asymmetry always refers to bilateral asymmetry between the selected limbs or movements in this review (Bishop et al., 2017). For example, isokinetic or isometric strength testing could assess hip flexion strength asymmetry by comparing hip flexion strength in the intact limb to that of the residual limb. A systematic review examining the effects of muscle asymmetries on physical and sports performance found that asymmetries greater than 15% have been associated with an increased injury incidence and decreased sports performance (Bishop et al., 2017).

Strength and Physical Activity. Just as strength is lost by being sedentary, it can be gained by being physically active. As described previously in the studies by Bäcklund et al. (1968) and Nolan (2009), people with TTA who are more physically fit and active are generally stronger than sedentary people with TTA, even when they have the same etiology of amputation. These same studies revealed that participating in PA may also reduce muscular asymmetry between the limbs (Bäcklund et al., 1968; Nolan, 2009). During a training study, Nolan (2012) found that a 10-week, twice weekly training protocol produced significant isokinetic hip flexion/extension strength gains in both the residual and intact limb. Additionally, hip extension asymmetry was decreased from 45% to 30% with the residual limb being weaker in both cases. In contrast to the strength gains and reductions in asymmetry found in the training group, the control group had significantly weaker hip extension in the residual limb following the 10-week protocol. Over the 10-week protocol, the control group was instructed to continue with their normal daily activities. Nolan's protocol consisted of a stationary bike warm-up, balance and co-ordination exercises, hip strengthening exercises, and a cool down (Nolan, 2012). The results of Nolan's (2012) study align with those found in the Hewson et al. (2020) review. Hewson et al. (2020) identified five strength training studies using participants with TTA; these studies used isokinetic, isometric, and strength training protocols with various training frequencies, repetition ranges, and exercise intensities. Regardless of the variables unique to each program, each protocol successfully increased lower limb strength and improved functional mobility when applicable (Hewson et al., 2020). These results are exceptionally positive as the reviewed studies used participants with vascular and non-vascular amputation etiologies, a wide average age range of participants (37.5-67.8 years), and a range of time since amputation (2.5-19 years).

Balance

Balance, often referred to as postural control, is described as the ability to maintain equilibrium and not fall over. Specifically, balance is the ability to keep the center of mass within the base of support (Pollock et al., 2000). The center of mass is the point in the body where weight is distributed evenly relative to the position of the trunk and limbs (Pollock et al., 2000). In humans, this point is dynamic and is constantly moving with each step, reach, and bend. The base of support is also dynamic, referring to the area making contact with the ground (Pollock et al., 2000). For example, the base of support changes constantly while running. Similarly, the base of support becomes more or less stable, the wider or narrower the stance. Balance also requires input from multiple sensory systems including the visual, vestibular, and somatosensory systems (Blackburn et al., 2000). Impaired proprioception and force production deficits have been identified as playing roles in the balance impairments following TTA (Bolger et al., 2014; Kavounoudias et al., 2005).

Proprioception. Proprioception is sensory information that helps your body to coordinate the limbs relative to each other. This sensory information is received by the body from the muscles, tendons, and joints via mechanoreceptors. Mechanoreceptors transduce mechanical load into afferent impulses that are carried along afferent axons to the central nervous system (CNS) and brain. These impulses provide the brain with critical information about joint angles and limb positions, helping to maintain joint stability and balance (Miura et al., 2004; Schmidt & Willis, 2007).

Kavounoudias et al. (2005) examined proprioception in a population living with TTA. Using a sample of 48 people with TTA and 48 age-matched healthy controls, proprioception was assessed using passive movement detection and touch-pressure sensibility testing. Passive movement detection uses an isokinetic testing machine to measure the minimum movement required for the participant to detect that their limb has been moved passively. In this study, the machine was set to rotate at 0.7°/s. Passive knee movement was assessed in the residual and intact limb as well as in one of the healthy control's legs (which leg was chosen at random). Passive ankle movement was also assessed in the same intact limb. Touch-pressure sensibility testing was also performed. These tests were performed using Semmes-Weinstein monofilaments for all trials. Three sites were assessed for touch-pressure sensibility for the participants with TTA: the proximal tibia on the residual and intact limbs and the sole of the intact foot. Healthy participants had the proximal tibia and sole of the foot assessed unilaterally. Results were stratified by amputation etiology into traumatic and vascular amputation groups (Kavounoudias et al., 2005). Statistically significant differences in proprioception (deemed anything greater than 2.5 standard deviations from the control group) were found for passive movement detection 25% of the time in the residual knee and 20% of the time in a participant's intact knee. No significant differences in passive movement threshold were found when stratified by amputation etiology. These results indicated that changes occurred in proprioception, not only in the residual knee, but also in the intact knee as well (Kavounoudias et al., 2005). These findings are contrary to previous research where proprioception deficits were found in the residual knee but not the intact knee (Liao & Skinner, 1995). It is likely that these differences are attributable to a slower passive movement speed (0.4°/s compared to 0.7°/s) in Liao and Skinner's (1995) study. Slower movement speeds have been shown to raise movement detection thresholds (Simoneau et al., 1996). Additionally, Liao and Skinner (1995) used an older population (mean 61 years of age) which may have allowed the effects of aging, including a known deficit in proprioceptive ability independent of amputation status, to skew the results (Kavounoudias et al., 2005; Liao & Skinner, 1995). In contrast, Kavounoudias et al. (2005), age-matched each participant and used a wider population age range (26-62 years), making it unlikely that their results were affected by participant age.

A loss of local proprioception due to amputation and a change in proprioception in the surrounding areas is expected due to the complete removal of the muscles, tendons, and joints of the foot, ankle, and lower leg, along with their associated mechanoreceptors. Specifically, the muscles of the foot and ankle, as well as the cutaneous mechanoreceptors of the sole of the foot, have been shown to play a large role in controlling posture and gait (Kavounoudias et al., 2001). The bilateral changes in proprioception detected are surprising because these adaptations occur in the intact limbs. The cause of these bilateral deficits has been hypothesized to be the result of a reorganization in the CNS. Kavounoudias et al. (2005) posit that these changes occur as an attempt by the CNS to equalize the somatosensory inputs received from the intact and residual limbs. Dampening the signals received from the intact limb may help the CNS better integrate stimuli bilaterally (Kavounoudias et al., 2005). Similar bilateral proprioceptive impairments have been detected following upper extremity amputation, knee replacement, and anterior cruciate ligament tears (Arockiaraj et al., 2013; Fuchs et al., 1999; Kavounoudias et al., 2005).

When examining touch-pressure sensibility at the sole of the foot, stratification by amputation etiology becomes important. The same study by Kavounoudias et al. (2005) found that 31% of vascular amputees were insensitive to the largest monofilaments on the sole of their foot whereas only 3% (one participant) with traumatic TTA displayed the same sensory deficits.

Vascular amputation is frequently accompanied by the neuropathic effects of PAD and these effects can likely be attributed to the higher threshold of touch-pressure sensibility found in people with TTA (Kavounoudias et al., 2005; Levin et al., 2020).

The functional effect that these proprioceptive changes have on people with TTA is unknown, as no studies have directly linked these sensory deficits to changes in functional outcome measures. Decreased proprioception has been linked to changes in limb biomechanics and neuromuscular control. Abnormal biomechanics and impaired neuromuscular control have been related to impaired balance, a higher risk of falling, and lower overall quality of lower body movement control (Ferlinc et al., 2019).

Force Production Deficits. The other primary factor believed to impact balance in people with TTA are force production deficits (Bolger et al., 2014). In typical walking, the calf muscles plantarflex the ankle during push-off, thereby contributing to forward movement. After amputation this is no longer possible. Similarly, force production deficits while standing have been examined by assessing postural sway, center of mass, and center of pressure measures (Bolger et al., 2014; Buckley et al., 2002; Nadollek et al., 2002).

Populations with non-PAD-related TTA have shown equal dynamic balance abilities when compared to healthy age-matched controls (Bolger et al., 2014). This was assessed using perturbations created by a force platform capable of horizontal surface translations. Each perturbation resulted in 9 cm of displacement moving at 35 cm/s. Surprisingly, dynamic balance capabilities were equal between the healthy group and group with TTA; however, dynamic balance was achieved using very different contributions from the residual and intact limb. Similar center of mass displacement was found when compared to controls, but center of pressure values for people with TTA were much greater on the intact side. Center of pressure mimics the movement of the center of mass which is constantly trying to maintain stability. These results indicate that the intact limb performs more stabilization of the center of mass during dynamic balance than the residual limb. It is not known if these force production deficits are the result of poor interaction with the prosthetic limb or a compensation strategy developed to improve stability (Bolger et al., 2014).

Seth and Lamberg (2017) identified several studies that compared populations with non-PAD-related TTA to those with PAD-related TTA. People with PAD-related TTA displayed greater postural sway than both healthy controls and people with traumatic TTA (Seth & Lamberg, 2017). Similarly, when examining center of pressure measures, Nadollek et al. (2002) found that participants with PAD-related amputation significantly favored their intact limb over their residual when compared to participants with non-PAD-related amputation. These results are not surprising as people with PAD-related TTA also live with comorbidities such as decreased strength, balance, and proprioceptive abilities. Interestingly enough, greater stance asymmetries in the PAD-related amputation populations have been associated with weaker hip abduction strength (Nadollek et al., 2002).

Balance and Physical Activity. Multiple training interventions designed to improve balance abilities have been implemented in populations with TTA. A pilot study by Matjacić and Burger (2009) had 14 participants with TTA complete five consecutive training days. Training consisted of 20 minutes of balance exercises using a BalanceReTrainer which, after training, improved the maximum duration participants could stand on their residual limb, as well as reduced times on the Timed Up and Go Test and 10-meter walk test. A BalanceReTrainer is a specialized balance training device that keeps participants safe from falling. The results indicated that the balance training protocol can improve balance, as shown in multiple tasks, in just five days (Matjacić & Burger, 2009).

Another training intervention implemented in a TTA population was completed by Kaufman et al. (2014). They used a task-specific fall prevention program that has proven to be successful in improving balance in elderly populations. Fourteen male military veterans with TTA were selected for the study, which consisted of six 30-minute training sessions completed over a two-week period using a specialized treadmill. The treadmill was connected to a computer to create a variety of perturbations ranging from not very challenging to extremely challenging where belt speed was suddenly increased or decreased. Three types of perturbations were used for this study. The static perturbation involved a perturbation while the participant was standing on the stationary treadmill; the participant was instructed to recover by taking only a single step. The static walk perturbation was similar to the static perturbation, but the participant continued to walk after recovering from the perturbation. Finally, the e-trip disturbance involved a perturbation while the participant was already walking on the treadmill. Perturbation intensity was guided by the participant's ability and was increased each session (Kaufman et al., 2014). The skills required to navigate the perturbations created by the treadmill are thought to be the same skills required to prevent a fall, such as resisting trunk rotation and quickly taking a long step. Eleven subjects completed the study (none of the dropouts were related to the training protocol), and of these 11 subjects, 10 failed the prescreening standard perturbation test. The standard perturbation test consisted of the treadmill creating a perturbation at a time unknown to the participant. If the participant recovered without the need of the treadmill safety harness, they passed. Participants who required assistance from the treadmill safety harness failed. Following the completion of the training protocol, each of the 11 remaining participants successfully completed the standard perturbation test. Six of the 11 were even confident enough to complete the perturbation test with their residual limb. These improvements were retained by participants six months after the final test. Most importantly, these results appear to have translated into improved functional mobility as well, with 60% of participants reporting a decrease in stumbles following training (Kaufman et al., 2014).

When considering the body of literature, balance ability, like strength, appears modifiable (Hewson et al., 2020). Unfortunately, many of these studies lack ecological validity, utilizing specialized treadmills and balance trainers. This equipment is great for laboratory research but is far too costly for the average person with TTA to access. More accessible training protocols still need to be developed and implemented to see if the benefits from these studies translate to the real world. Fortunately, the training protocols examined various populations with TTA and improvements in balance ability were detected in as little as five training sessions (Matjacić & Burger, 2009). Balance improvements also appear long lasting with the detected balance improvements from six training sessions retained for at least six months (Kaufman et al., 2014). Improving balance in people with TTA is essential as 57.6% of people with TTA report having fallen in the past 12 months (Kim et al., 2019). Diminished balance abilities have also been associated with reduced functional mobility (Kavounoudias et al., 2005).

Functional Mobility

The combination of the anatomical changes, strength deficits, and balance impairments experienced following TTA have a noticeable impact on functional mobility (Hewson et al., 2020; Kavounoudias et al., 2005). Functional mobility refers to one's physiological capability to safely accomplish activities of daily living both at home and in the community (Bouça-Machado et al., 2018). Changes in functional mobility have been quantified using multiple outcome measures including gait deviations, decreased walking speeds, and increased energy consumption.

Gait Deviations. Gait deviations in populations with TTA have been quantified by examining kinematic asymmetries and force production deficits (Bolger et al., 2014). Kinematic asymmetries are the most visually apparent change in functional mobility. These deviations include a significantly longer step length, step time, and swing time on the intact side, along with a significantly shorter stance time and single leg support time on the residual side (Bolger et al., 2014). When examining force production during gait, the anatomical changes of TTA resulted in reduced ankle power and reduced power output from the residual limb during the push-off phase of gait. Typically, the ankle plantarflexes during push-off in walking, allowing the calf muscles to assist during forward motion, however, after amputation this is not possible. The reduced push-off power at the ankle results in an overall reduction in the amount of work being performed by the residual limb. This reduced push-off power results in the aforementioned shorter stride length with the residual limb (Bolger et al., 2014). This results in above-average power loss upon heel-strike with each step as well. In order to compensate for the lack of force production and excess power loss, the missing power must be produced elsewhere to maintain walking speed (Houdijk et al., 2009). This results in longer intact limb stance times, greater power production, and excessive knee flexion in the intact limb during push-off (Beyaert et al., 2008; Bolger et al., 2014). Knee flexion in the intact limb was also reported to be greater than in the residual limb and healthy controls (Beyaert et al., 2008).

Many interventions have been designed to reduce gait deviations in people with TTA. A systematic literature review examining gait training in people with LEA found a great deal of variability amongst the design of these studies (Highsmith et al., 2016). The common theme extracted from the 18 studies selected was that any gait training program prescribed by a knowledgeable healthcare professional was successful in improving both functional mobility and reducing gait asymmetry. Both treadmill training and ground-based training protocols were effective (Highsmith et al., 2016).

Energy Expenditure. Not surprisingly, the compounding effects of amputation, impaired strength and balance abilities, use of a prosthetic, and a modified gait pattern resulted in an increased energy demand (Schmalz et al., 2002). One outcome measure commonly used to assess energy expenditure is preferred walking speed. Preferred walking speed is an outcome measure often used to highlight the physical capacity differences between populations, such as different levels of LEA, or between people with TTA and healthy controls. An individual's preferred walking speed typically occurs at the speed that minimizes the individual's cost of transport (metabolic rate/locomotion speed; Gast et al., 2019). Individuals with slower preferred walking speeds have greater energy demands during locomotion than those with faster preferred walking speeds. These energy demands are affected by many factors including strength, balance, and level of amputation (Crozara et al., 2019; Raya et al., 2010). Research in older adult populations has shown that slower preferred walking speeds result in reduced daily ambulatory activities (Middleton et al., 2016). The strongest predictor of preferred walking speed was muscle strength, specifically isokinetic hip extension and abduction power. These two factors accounted for 82% of the variance in preferred walking speed (Crozara et al., 2019). Individuals living with TTA walk faster (1.7 m/s) than transfemoral amputees (0.78 m/s). Preferred walking speed has been shown to decline with age (Weber, 2016). As such, studies with age-matched healthy controls are required to determine if people with TTA walk slower than healthy participants. (Jones et al., 1997; Samson et al., 2001; Serizawa et al., 2016; Ward & Meyers, 1995).

Another measure of energy expenditure is oxygen consumption. Although people with TTA consume similar amounts of oxygen as healthy controls while standing, during gait, people with TTA consume up to 25% more oxygen than healthy controls (Schmalz et al., 2002). Nolan (2012) conducted a study in which amputees completed a 10-week home training program. The protocol consisted of a stationary bike warm-up, balance and co-ordination exercises, hip strengthening exercises, and a cool down. He found that significant reductions in oxygen consumption were made compared to baseline oxygen consumption over the course of the training period. These reductions were not significant, however, when compared to healthy controls (Nolan, 2012). No pre- or post-protocol measures of balance were used in this study, so the impact this protocol had strictly on balance ability cannot be determined. Of note, of the participants with TTA, only one had the ability to run pre-study. Post-study three of the four participants were able to run unassisted. Participant's regaining the ability to run indicates a decrease in energy expenditure, increased lower limb strength, and overall improvement in functional mobility (Nolan, 2012).

Psychosocial Adaptation to Transtibial Amputation

As previously mentioned, adapting to the anatomical changes of TTA is both a physical and a psychosocial process. Although the physical effects of TTA (discussed above) are life changing, adjusting to the psychosocial effects of TTA has been considered even more difficult to endure (Randolph et al., 2014). Psychosocial adaptation to amputation is related to multiple psychosocial domains including balance confidence, depression, anxiety, and body image issues. In populations with TTA, psychosocial adaptation to amputation is considered a key determinant to QoL (Luthi et al., 2020).

Balance Confidence

Following TTA, not only are the balance abilities of people with TTA impaired, but so is their balance confidence. Balance confidence is a unique psychosocial factor related to both functional mobility and participation in community activities (Mandel et al., 2016). Social participation, such as participating in community activities, is an important factor related to improved psychosocial adaptation and is an important predictor of QoL (Asano et al., 2008). Balance confidence is not a true measure of balance, instead assessing an individual's perceived balance. This concept was developed based on Bandura's Theory of Self-Efficacy (1977). In this theory, self-efficacy revolves around an individual's belief that they can accomplish their goals and have autonomous influence over the events that affect their life. Without this core belief, there is little incentive to try new things or overcome adversity (Bandura, 2010). As it applies to balance, balance confidence refers to an individual's belief that they can complete a task without falling (Mandel et al., 2016).

Strength and proprioception changes following TTA result in decreased balance abilities. This aligns with 57.6% of people with TTA who reported falls in the past 12 months (Kim et al., 2019). Despite this high rate of falls, falling was not found to be associated with decreased community participation in TTA populations. Even the fear of falling does not decrease community participation when balance confidence is accounted for (Landers et al., 2016). Higher balance confidence scores have been associated with higher levels of PA and greater physical fitness. A greater risk of falling, however, has been found in people with high actual balance ability when compared to their less confident peers (Wong et al., 2015). In contrast, individuals with low balance confidence may actively avoid PA to limit falls and the associated pain (Mandel et al., 2016).

Limited studies have assessed balance confidence before and after a training intervention. One study using a population with TTA was identified. As previously discussed, Kaufman et al. (2014), assessed a fall prevention training program for people with TTA. Following completion of the training protocol, each of the 11 remaining participants successfully completed the standard perturbation test. Six of the 11 participants were even confident enough to complete the perturbation test with their residual limb. These improvements were retained by participants six months later. Although the confidence to complete the perturbation test on both limbs appeared to indicate an increase in balance confidence, when quantified with the Activities-specific Balance Confidence Scale (ABC), no significant differences between the pre- and post-test were reported. It is likely that the population selected for this study (military veterans) were experiencing a ceiling effect with the ABC as the average score was 90/100.

The ABC has detected an improvement in balance confidence following a training intervention implemented in a population of elderly women. Ninety-eight women were assigned to one of three training groups including resistance training, agility training, or stretching exercises. The stretching group was used as a control group as there is no evidence that stretching can reduce the risk of falling or improve balance confidence. Each session was 50 minutes in length and completed twice weekly for 13 weeks. Both the resistance and agility training groups showed significant improvements in balance confidence when compared to their pre-test scores (Liu-Ambrose et al., 2004).

Depression

One of the most researched psychosocial domains regarding people with TTA is depression. Depression is a common but underdiagnosed mental health disorder, with symptoms including a depressed mood, loss of interest and pleasure, weight loss/gain, insomnia/hypersomnia, restlessness/sluggishness, feelings of guilt or worthlessness, loss of concentration, indecisiveness, or suicidal thoughts (McCarter, 2008). Depression, if left untreated, can lead to an increased need for medical care and hospitalization, a greater chance of unemployment, and an increased risk of suicide (McLaughlin, 2011).

Individual studies have found depression rates to be higher in people with TTA than in general populations. Horgan and MacLachlan (2004), however, observed a different trend regarding depression and lower limb amputation. In the time immediately following amputation, depression rates in people with a lower limb amputation were abnormally high; however, it has been argued that short-term depression could be a normal reaction to losing a limb. High rates of depression persist following TTA for the next two years, but, two years after TTA, depression levels have been found to be comparable to age-matched controls in the general population (Horgan & Maclachlan, 2004).

The higher rates of anxiety and depression found following TTA are believed to occur as a natural part of limb loss and adaptation to TTA. Transtibial amputation is a traumatic event, and the shock of that event can exacerbate the psychosocial effects of the amputation itself. As people with TTA adapt to their new appearance and function, individuals often wish for the restoration of their lost limb and are ashamed of their amputation (Norris et al., 1998). As individuals with amputation reimagine their self-image, they accept their physical changes as a part of their new identity, and accept their amputation as a part of who they now are. This process typically occurs over the 18-month period post-amputation (Norris et al., 1998). This 18-month period aligns with the elevated rates of depression found in the first two years post-amputation. Although adaptation to amputation occurs rapidly in the first 18-months post amputation, adaptation to amputation is not considered complete without the reimagining of one's self-image. Adaptation to amputation is a lifelong process related to multiple factors including the physical restrictions caused by the amputation, psychosocial restrictions such as depression, anxiety, and body image issues, as well as the function of the prosthetic limb itself (Gallagher & Maclachlan, 2000).

Anxiety

Anxiety is another common and underdiagnosed mental health disorder. Anxiety has a comorbid relationship with depression where 85% of people with depression have anxiety related disorders. Likewise, 90% of patients with anxiety have depression (Tiller, 2013). Symptoms such as insomnia/hypersomnia, restlessness/sluggishness, feelings of guilt or worthlessness, loss of concentration, indecisiveness, or suicidal thoughts are common between depression and anxiety. The primary difference between anxiety and depression is that anxiety is predominantly associated with excessive worry, where depression is predominantly related to apathy and loss of interest (Substance Abuse and Mental Health Services Administration, 2016).

No training studies examining depression or anxiety and PA in populations with TTA were found during a review of the literature. A literature review on the effects of exercise and PA on depression found that PA has a comparable effect on depression as the use of antidepressant medications (Dinas et al., 2011). Exercise causes the body to begin releasing ß-endorphin. ß-endorphin is an endogenous opioid compound released by the pituitary gland (Dinas et al., 2011). Although the mechanism is yet to be confirmed, it is hypothesized that higher levels of ß-endorphin circulating in the blood have been associated with reduced pain levels and increased analgesia. Analgesia in turn reduces depression and anxiety levels. This theory provides a physiological mechanism for PA to help reduce depression and anxiety levels (Dinas et al., 2011). In addition to this potential physiological effect, the social aspects of PA have also been shown to reduce depression and anxiety (Horgan & Maclachlan, 2004).

Body Image Distortion

A person's body image refers to how they view themselves. Personal feelings about their function, appearance, and desirability combine with their psychological experiences and environmental factors to create their body image (Horgan & Maclachlan, 2004). Body image distortion occurs when their self-image does not align with reality. It is common for people with an amputation to experience body image distortion as they have just experienced a major life change. People who have body image distortion are more likely to experience anxiety and depression, and they also have a lower QoL and poorer self-esteem (Horgan & Maclachlan, 2004).

Until people who have TTA and body image distortion accept their limb loss as a part of who they now are, they will continue to struggle with their body image and new identity. No training studies regarding PA and body image distortion were found; however, Wetterhahn et al. (2002) compared the body image of active people with a LEA to sedentary people with a LEA. They found a significant difference between body image and PA participation. Although this study was only cross sectional it provided evidence that body image distortion can be improved through PA (Wetterhahn et al., 2002).

Engagement in Physical Activity

As a population, people with TTA are generally unfit. Strength loss, functional mobility impairments, and poor psychosocial adaptation to TTA are also common following TTA. Those who live a sedentary lifestyle have been shown to experience exacerbated effects (Buckley et al., 2002; Hewson et al., 2020; Kaufman et al., 2014). Even still, only 32% of people with TTA participate in PA, and when they do, they rarely meet the recommended minimum requirements (Kars et al., 2009; Langford et al., 2018). Fortunately, just as a sedentary lifestyle exacerbates the effects of TTA, participating in PA has been shown to reduce them. The literature compiled for this review reveals that most of the effects of TTA are modifiable (Hewson et al., 2020). Physical activity has been documented to improve the physical effects of TTA such as impaired lower limb muscle strength, impaired balance ability, and functional mobility changes (Matjacić & Burger, 2009; Nolan, 2012). Physical activity also has a positive effect on the psychosocial effects of TTA such as impaired balance confidence, and the domains of psychosocial adaptation to amputation such as depression, anxiety, and body image issues (Hewson et al., 2020; Kaufman et al., 2014). The benefits of PA are so numerous, it has been considered one of, if not, the best thing a person can do to maximize both their life and heath span (Booth et al., 2012).

Avoidance of Physical Activity

In general, living a sedentary lifestyle shortens the lifespan, promotes sarcopenia, and the development of chronic disease; but avoiding PA, out of fear of pain, only makes matters worse (Booth et al., 2012). Most people with TTA already live with reduced lower limb strength and have chronic disease as a comorbidity (such as obesity, diabetes, or PAD; Hewson et al., 2020). Avoiding PA out of fear can further create additional negative health impacts to the already deadly effects of a sedentary lifestyle (Mathis, 2020).

No studies examining PA avoidance in populations with TTA were found but in a population with LEA, avoidance of PA was associated with pain catastrophizing and mobility apprehension. Pain catastrophizing was also the only variable related to mobility apprehension, as even pain intensity was not related to mobility apprehension (Landers et al., 2016). Pain catastrophizing refers to deeply focusing on and anticipating the feeling of pain. Typically, this involves magnifying the fear of pain and anticipating a worst-case scenario. This worst-case scenario creates fear and mobility apprehension. Mobility apprehension is a fear of movement and this fear may lead to the avoidance of movement, and then possibly into disuse, disability, and depression (Vlaeyen et al., 1995). Although pain catastrophizing is a psychosocial phenomenon, the effects can manifest physically. Pain catastrophizing leads to mobility apprehension and higher levels of pain, depression, and disability. Mobility apprehension encourages a sedentary lifestyle and exacerbation of the physical effects of TTA such as further muscular deconditioning, further balance reductions, and a higher rate of falling (Landers et al., 2016).

Purpose of the Research

While a large body of literature exists highlighting the benefits of PA for people living with TTA, many people with TTA do not participate in PA. Review of the literature reveals that strength, balance, and functional mobility are impacted by TTA. These effects are not purely physical either, as TTA also effects psychosocial domains such as balance confidence, anxiety, depression, and body image. The benefits of PA are both physical and psychosocial in nature, showing a positive relationship between higher PA levels in people living with TTA and higher levels of balance confidence (Mandel et al., 2016; Miller et al., 2001). Individuals with higher balance confidence also have a greater risk of falling when compared to their less confident peers (Wong et al., 2015). It has been speculated that people living with TTA who have low balance confidence may actively avoid PA to avoid falling and the associated pain that comes with it (Mandel et al., 2016). This relationship has been detected in people with LEA avoiding stressors in general, but not in an exclusively TTA population or in the context of PA (Desmond & MacLachlan, 2006). It is also possible that other factors related to physical and psychosocial adaptation to amputation such as depression, anxiety, or an overall lack of mobility are responsible for the avoidance of PA in people living with TTA.

The exercise avoidance patterns of people living with TTA has received little research and attention. As such, the purpose of this study was to explore the relationship between balance confidence and the physical and psychosocial effects of TTA and how this is related to PA participation and avoidance habits.

Guiding Questions

The following questions were developed to guide this study:

1. Is there a relationship between balance confidence and participation in PA?
2. Is there a relationship between balance confidence and avoidance of PA?
3. Is there a relationship between the physical and psychosocial adaptation to unilateral TTA and participation in PA?
4. Is there a relationship between the physical and psychosocial adaptation to unilateral TTA and avoidance of PA?

This study provides researchers and healthcare providers with insight into the PA participation and avoidance habits of people with TTA and how they relate to balance confidence and the physical and psychosocial effects of TTA. To measure these constructs, several validated and reliable scales were used. To measure balance confidence, the Activities-specific Balance Confidence Scale (ABC) was used. The physical and psychosocial adaptation to TTA was measured with the Trinity Amputation and Prostheses Experiences Scale-Revised (TAPES). Participation in PA was measured using the Baecke Physical Activity Questionnaire (BAQ). And avoidance of PA was measured using the Tampa Scale for Kinesiophobia (TSK). Psychometric properties of these scales are given below.

Chapter Three: Methodology

The purpose of this study was to explore the relationship between balance confidence and the physical and psychosocial effects of TTA and how this related to PA participation and avoidance habits. Participants completed an online survey consisting of several scales that measured physical and psychosocial adaptation to amputation, balance confidence, participation in PA, and avoidance of PA using the TAPES, the ABC, the BAQ, and the TSK scales, respectively. Statistical analyses were performed to examine the relationship among the variables of balance confidence and physical and psychosocial adaptation to TTA to the dependent variables of participation in or avoidance of PA. All procedures were approved by the Lakehead University Research Ethics Board in accordance with the Declaration of Helsinki.

Participants

This study consisted of 21 participants, each participant had undergone TTA, resided in Canada, and was over the age of 18 years. Only those with unilateral TTA and had undergone amputation more than six months ago were included.

Psychometric Properties of Survey Instrumentation

The Trinity Amputation and Prostheses Experiences Scale- Revised

The TAPES was used to ensure the inclusion and exclusion criteria for this study were met (Appendix A). Some items on the TAPES were also used to aid the student researcher in providing more accurate insights into the relationship between people living with TTA, their PA habits, and different demographic groups.

In addition to a screening tool, the TAPES was used as an instrument to assess physical and psychosocial adaptation to TTA. The TAPES is a valid and reliable, multidimensional self-report tool (Gallagher & Maclachlan, 2000). It was used to assess how TTA has affected the physical and psychosocial wellbeing of the participants. The TAPES consists of six subscales, providing six individual scores that do not aggregate to one overall score. Three psychosocial subscales consisting of five questions scored on a 5-point Likert scale (1-5) where 1 represents *strongly disagree* and 5 represents *strongly agree*. The psychosocial subscales measured general adjustment, social adjustment, and adjustment to limitation. There was an activity restriction subscale, consisting of four questions scored on a 3-point Likert scale (2-0). Two represents activity is *highly limited* and 0 represents *activity is not limited at all*. Finally there were two prostheses satisfaction subscales, functional satisfaction and aesthetic satisfaction, consisting of five questions scored on a 5-point scale (1-5). One represents *very poor* and 5 represents *very good*. Each subscale is scored separately and can be used on its own, while these six scores together represent a multidimensional assessment of a participant's physical and psychosocial adaptation to LEA (Gallagher & Maclachlan, 2000). The TAPES has been validated against the World Health Organization's QoL scales, accounting for 84% of the variance (Gallagher & Maclachlan, 2004). Construct validity has also been assessed by correlating subscale scores with QoL, body image satisfaction, anxiety, and depression. Internal consistency is acceptable with Cronbach's α greater than .80 for each subscale (Luthi et al., 2020). The TAPES has also been found to be reliable with intraclass correlation coefficients (ICC) of .87, .84, and .76 reported for the functional, social, and athletic restriction subscales, respectively (Gallagher & Maclachlan, 2000). A strong relationship has been detected between other psychosocial factors (QoL, pain, body image satisfaction, anxiety, and depression) and improved adaptation to amputation (Luthi et al., 2020). The TAPES is free to access and requires no equipment to complete. In total, the TAPES consists of 64 items and can be completed in approximately 15 minutes.

The Activities-specific Balance Confidence Scale

The ABC was used to assess balance confidence (Appendix B). It was developed by Powell and Myers in 1995 to provide a sensitive measure for fear of falling in elderly populations and has since been validated for use in TTA populations (Miller et al., 2003). The ABC is a 16-item list. Each item was rated from 0% to 100%, where 0% represents no confidence and 100% represents full confidence. Once complete, the scores from each question were summed and then divided by 16 to obtain the average percent score for all items. Scores lower than 50% indicated low balance confidence, scores between 50% and 80% indicated moderate balance confidence, and scores above 80% indicated high balance confidence. The ABC has been shown to have excellent validity in the TTA population, which is consistent with its validity found in other populations (Miller et al., 2003; Park et al., 2018). The ABC also has a high test-retest reliability (r=.91) and a high internal consistency measured using Cronbach's α equal to .95 (Miller et al., 2003). The ABC can be completed in approximately five minutes, requires no equipment, and is free to access.

The Baecke Physical Activity Questionnaire

The BAQ was used to assess the participant's PA habits over the past 12 months (Appendix C). It consists of 16 questions separated into three dimensions. The three PA dimensions include work activity, sports activity, and leisure activity. Activity levels were scored on a scale from 1 to 5. One always represents the lowest activity response. Five always represents the response with the highest activity. Individual index scores were summed to give an overall BAQ score. There is no "gold standard" self-report assessment of PA. In general, activity monitoring devices are much more accurate tools for quantifying PA than self-report (Hertogh et al., 2008). However, the BAQ has been shown to have a fair-to-moderate correlation with PA ratio (total energy expenditure and resting metabolic rate) at .54 in elderly populations (Hertogh et al., 2008). The BAQ has also been validated in adult women with hip disorders, showing a fair to moderate correlation with step count and excellent test-retest reliability (Ono et al., 2007). The BAQ has not previously been used in a TTA population, though it has been used in people with type 2 diabetes who have peripheral neuropathy and foot deformities (Adeniyi et al., 2015). Additionally, the BAQ has been used to help validate a continuous ambulatory activity monitor for people with LEA caused by malignancy (Van Dam et al., 2001). The BAQ can be completed in approximately 20 minutes, requires no equipment, and is free to access.

The Tampa Scale for Kinesiophobia

The TSK was used to assess the participant's avoidance of exercise habits (Appendix D). Kinesiophobia is defined as excessive, irrational, and debilitating fear of physical movement and activity resulting from a feeling of vulnerability to painful injury or re-injury. The TSK consists of 17 questions. Each question is a statement regarding the individual's perceptions of exercise scored from 1 to 4 where 1 represents the participant *strongly disagrees* and 4 represents the participant *strongly agrees*. The participant's scores for each statement were then summed, with scores ranging from 17-68. Scores below 37 indicate kinesiophobia, or a fear of PA. The TSK is based on the fear avoidance model. This model attempts to explain how and why some people develop a more significant psychological effect than others, suggesting that avoidance of pain because of fear can lead to adverse physical and psychological consequences. This model has been widely used and supported (Lethem et al. 1983). The TSK has been used but not validated in TTA populations (Mathis, 2020). The TSK has been validated for other pathological populations such as chronic pain and fibromyalgia (Goubert et al., 2004). Additionally, the TSK has been shown to have high reliability and internal consistency measured using Cronbach's

α=.81 and ICC values=.91 (Lundberg et al., 2004). The TSK can be completed in approximately 5 minutes, requires no equipment, and is free to access.

Research Recruitment Procedure

Participants were recruited for this study using indirect purposive sampling, direct convenience sampling, and snowball sampling. As the targeted population was limited to people living with TTA across Canada, indirect purposive sampling was completed through the use of gatekeepers. In total, 213 gatekeepers were identified. In this study, gatekeeper refers to the Canadian Amputee Hockey Committee, the Amputee Coalition of Toronto, the Canadian National Para Hockey team, The War Amps Canada, and 209 orthotic and prosthetic clinics across Canada. Of these 209 orthotic and prosthetic clinics, 78 were found to be closed or offered no prosthetic services. Individuals with TTA are not typically clients at orthotic clinics, therefore, these clinics were not asked to help recruit participants. The remaining 131 prosthetic clinics were contacted by the student researcher. It was requested that clinics assist in the recruitment process by hanging the recruitment poster on a display board in their waiting area, directing any potential participants to the student researcher's email and the QR code on the poster that contained the survey information. In total, 29 gatekeepers assisted with the recruitment process, resulting in 27 potential participants. Of these 27 potential participants six were deemed ineligible. In total, 21 participants completed this study (see Figure 1).

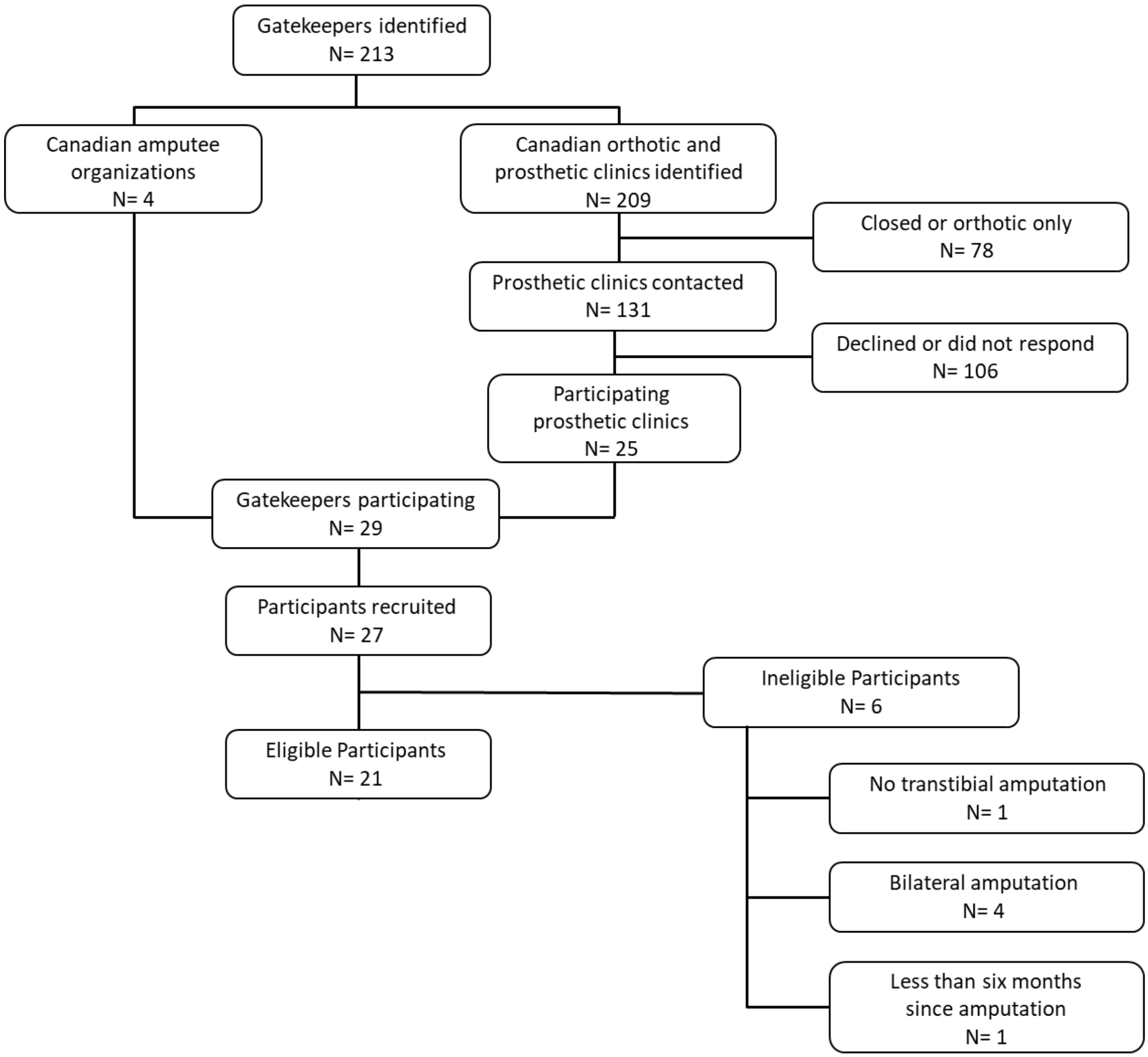

Figure 1. CONSORT Flow Diagram of the participant recruitment process and resultant participant inclusion.

Experimental Procedure

Once ethical approval from Lakehead University was attained, participant recruitment began. Participants were sent a link to the survey, containing the participant information letter, informed consent form, and study questionnaires were sent to participants via email to assess their balance confidence, physical and psychosocial adaptation to amputation, PA participation habits, and PA avoidance habits. Since this study was entirely survey based, all relevant study information was sent in one package, making participation in the study more convenient for the participants. Screening questions were placed at the start of the survey in an attempt to prevent any ineligible participants from completing the survey.

Data for this study were collected in a single session. All surveys were completed using Google Forms, allowing participants to complete the survey from wherever they resided. The first page of the survey was an information sheet providing an overview of the study, followed by the informed consent form. If at any time the participant had questions that were not covered by the information sheet, they were free to contact the student researcher via email for clarification, but that did not occur in this experiment. If the participant chose to participate in the study, they filled in the online consent form and then carried on to the questionnaires for the study.

The first section of the survey was the TAPES, which collected demographic information about the participants including all relevant inclusion and exclusion criteria for this study (had undergone TTA, resided in Canada, were over the age of 18 years, did not have bilateral amputation and had not undergone TTA in the past six months). Question one from the TAPES (participant name) was removed to protect participant anonymity. Questions four (do you live in Canada?) and eight (do you have amputations on both legs?) were added to the TAPES to ensure all of the inclusion and exclusion criteria were addressed. Once the demographics section of the TAPES was completed, participants were free to complete the rest of the survey. The rest of the survey contained the remaining sections of the TAPES, followed by the ABC, the BAQ, and the TSK scales.

Statistical Analysis

Results from each of the survey questionnaires were quantified according to the scoring criteria of the instrument. Statistical analyses were completed using commercially available software (IBM SPSS 27, Chicago, IL, USA). Descriptive statistics were also completed using the screening questions from the TAPES on age, gender, years since amputation, and etiology of amputation.

Research questions were answered using both the Pearson correlation and the Spearman rank correlation for normally and non-normally distributed data, respectively. The Spearman rank correlation is a non-parametric test that measures the association of two variables. This test does not make assumptions about the data distribution and is the appropriate correlation analysis when the variables are measured on an ordinal scale and are non-normally distributed. The Pearson correlation is a parametric test that measures the association of two variables. This test makes assumptions about the data distribution and is the appropriate correlation analysis for ordinal data when the variables are normally distributed (Field, 2009).

For the first research question, the variable balance confidence (ordinal; measured by the ABC) was compared to the variable participation in PA (ordinal; measured with the BAQ). For question two, the variable balance confidence (ordinal; measured by the ABC) was compared to the variable avoidance of PA (ordinal; measured by the TSK). For question three, the variables related to physical and psychosocial adaptation to unilateral TTA (ordinal; measured by the TAPES) were compared to the dependent variable participation in PA (ordinal; measured by the BAQ). For question four, the variables related to physical and psychosocial adaptation to unilateral TTA (ordinal; measured by the TAPES) were compared to the variable avoidance of PA (ordinal; measured by the TSK).

Bivariate correlations were significant at $\alpha=.05$. Statistical power was inferred from r and r_s from the statistical values indicating effect sizes (Field, 2009). Results from the correlation coefficients ranging between .1 and .3 were considered a low effect size, correlations ranging from .3 to .5 were considered to be a moderate effect size, and correlations greater than .5 were considered to be a large effect size (Field, 2009). Statistical significance was accepted at $p <.05$.

Chapter Four: Results

This study provided evidence of a statistically significant relationship between balance confidence and PA participation. No evidence of a relationship between balance confidence and PA avoidance habits was detected. The results of this study also provided evidence of multiple statistically significant relationships between the physical and psychosocial effects of TTA and PA participation and avoidance habits. Outcomes of each statistical test are detailed below.

Demographics

A total of 21 participants completed this study. Demographic information for all participants is provided in Table 1.

Table 1.
Participant demographic information.

Gender	14 male, 6 female, 1 non-binary
Ethnicity	18 Caucasian, 1 Indigenous, 1 Arabic, 1 other
Age (years)	55.10 +/- 9.45
Province of Residence	13 Ontario, 6 Alberta, 1 British Colombia, 1 Quebec
Time Since Amputation (years)	19.68 +/- 17.48
Cause of Amputation	8 trauma, 3 cancer, 4 PAD, 4 other, 1 congenital, 1 prefer not to answer
Time with Current Prothesis (years)	3.42 +/- 3.50

Missing Data

One participant did not include their age in the survey and one participant did not complete the social adjustment section of the TAPES. As a result, correlations on the variables Age and social adjustment were performed with the blank response removed. Data was reanalyzed using the sample's mean age and social adjustment values. Analysis completed using the missing data or using the mean data did not change the overall outcomes.

A total of nine participants reported themselves as retired. As a result, their responses for the work index were left blank or not considered valid. Fortunately, the sport and leisure indices are both valid tools individually and did not require a work index score to be interpreted. To account for non-working individuals the work index was removed from the data analysis (Florindo & Latorre, 2003). Overall BAQ scores were subsequently calculated with just the sport and leisure indices and were subsequently scored out of 10. As a result, correlations with overall BAQ scores did not reveal any statistically significant relationships that were not detected by correlations with the individual indices. For this reason, the indices from the BAQ were examined individually, not as an overall score.

Descriptive Statistics

Mean scores, standard deviations and participant counts for the ABC, TAPES, BAQ, and TSK are presented in Table 2.

Table 2.
Mean Scores for the ABC, TAPES, BAQ, and TSK

	Mean	SD	N
ABC Score	68.3	25.56	21
TAPES Scores			
General Adjustment	3.2	0.66	21
Social Adjustment	3.2	0.71	20
Adjustment to Limitation	2.3	0.94	21
Activity Restriction	1.0	0.59	21
Aesthetic Satisfaction	2.3	0.68	21
Functional Satisfaction	2.2	0.49	21
BAQ Score	4.6	1.49	21
Sport Index	2.2	0.91	21
Leisure Index	2.4	0.75	21
TSK Score	38.7	10.92	21

A frequency table is presented in Table 3 which details the self-reported sports participation scores. In total, twelve of the 21 participants (57.2%) reported no participation in sport; nine of the 21 participants (42.8%) reported participating in at least one sport; and five participants (23.8%) reported participating in at least two sports. Sports active participants engaged in an average of 10.4 (7.95) hours of sport each week and engaged in sports an average of 9.8 (2.86) months per year.

Table 3.
Sports Participation Frequency

Sport	Participants
Trapping and skeet shooting	1
Fishing	1
Tennis	1
Downhill Skiing	1
Golf	4
Walking	1
Motorsports	1
Wheelchair Curling	1
Hockey	1
Running	2
CrossFit	1

From other demographic questions (not in tabular form), most participants also reported living with some type of pain. Of the 21 total participants, 20 reported living with chronic pain. Stump pain was reported in 61.9% participants, phantom limb pain was reported in 61.9% participants, and 57.1% participants reported living with other medical problems such as friction blisters (23.8%), hip pain (14.2%), or lower back pain (14.2%). Pain levels ranged from mild to excruciating, with the average episode lasting from seconds to hours, or nonstop pain.

Normality of the data distribution from all survey instruments was assessed using the Shapiro-Wilk Test. Results are presented in Table 4. The results from the demographic information, as well as the social adjustment and aesthetic satisfaction sections from the TAPES, and the results from the ABC were not normally distributed, violating parametric assumptions. The results from the remaining TAPES items, the BAQ, and the TSK were normally distributed.

Table 4.

Results from the Shapiro-Wilk results.

	N	Statistic	p-value
Age	20	.85	.005*
Gender	21	.66	.000*
Ethnicity	21	.43	.001*
Province	21	.68	.000*
Time Since Amputation	21	.86	.006*
Cause of Amputation	21	.84	.003*
Time with Current Prosthetic	21	.76	.000*
Stump Pain	21	.62	.000*
Phantom Limb Pain	21	.62	.000*
Other Chronic Pain	21	.63	.000*
ABC Score	21	.89	.027*
General Adjustment	21	.92	.113
Social Adjustment	20	.89	.031*
Adjustment to Limitation	21	.91	.065
Activity Restriction Scale	21	.95	.399
Aesthetic Satisfaction	21	.85	.004*
Functional Satisfaction	21	.93	.122
Sport Index	21	.95	.273
Leisure Index	21	.93	.166
TSK Score	21	.96	.501

*Indicates survey results are significantly different from a normal distribution.

Relationships Between Outcome Variables

Correlations based on the research questions between the demographic information collected, the TAPES subscales, the ABC, the TSK, and the BAQ were completed using a Pearson correlation for normally distributed variables and a Spearman correlation for non-normally distributed variables. Full results are presented in Appendix E. Significant results are explained in the subsequent text. Table 5 contains the results of correlational analysis between adjustment to limitation, activity restriction, and functional satisfaction with the sport index, the leisure index, and the TSK.

Balance Confidence

This section answers the research questions "Is there a relationship between balance confidence and participation in PA?" and "Is there a relationship between balance confidence and avoidance of PA?".

Data collected for balance confidence revealed the mean balance confidence score was 68.3 (SD=25.56). Data collected for balance confidence were non-normally distributed, as assessed by Shapiro-Wilk's Test (p=.027). For this reason, a Spearman correlation was used to analyze data. The Spearman correlation found a statistically significant relationship between balance confidence and participation in PA, specifically the sport index (r_s=.48, n=21 p=.029). An r value of .48 indicates a positive relationship with a moderate effect size.

Data for participation in PA (the leisure and sport indices) and avoidance of PA (the TSK) were normally distributed, as assessed by Shapiro-Wilk's Test (p >.05) thus Pearson correlations were conducted comparing balance confidence to the sport and leisure indices. No statistically significant relationships were detected between balance confidence and the sport (p >.05) or leisure indices (p >.05). No statistically significant relationships were found between balance confidence and the TSK using the Spearman (p >.05).

Physical and Psychosocial Adaptation to Transtibial Amputation

This section answers the research questions “Is there a relationship between the physical and psychosocial adaptation to unilateral TTA and participation in PA?” and “Is there a relationship between the physical and psychosocial adaptation to unilateral TTA and avoidance of PA?”.

Physical and psychosocial adaptation to TTA consists of six measures including general adjustment, social adjustment, adjustment to limitation, activity restriction, aesthetic satisfaction, and functional satisfaction. Data from these measures revealed several statistically significant correlations with PA participation (the sport and leisure indices) and PA avoidance (the TSK). These correlations could be used in support of the construct validity of the TAPES in TTA populations, providing evidence for both convergent and divergent validity, however, as this was not the main intent of this study, only statistically significant correlations with other outcome measures will be discussed below.

General Adjustment. Data collected for general adjustment were normally distributed, as assessed by the Shapiro-Wilk’s Test ($p > .05$). For this reason, a Pearson correlation was conducted to compare general adjustment to and participation in PA. General adjustment showed a statistically significant correlation with the avoidance of PA ($r=.54$, $n=21$, $p=.012$). An r value of .54 indicates a positive relationship with a large effect size. General adjustment was not statistically significantly correlated with either of the PA measures, the sport index ($p>.05$) or the leisure index ($p>.05$).

Social Adjustment. Data collected for social adjustment were non-normally distributed, as assessed by the Shapiro-Wilk’s Test ($p<.01$). For this reason, a Spearman correlation was used to analyze data. The Spearman correlation found a statistically significant relationship between social adjustment and PA participation, more specifically the sport index (r_s=.46, *n*=21, *p*=.042). A r_s value of .46 indicates a positive relationship with a moderate effect size. As the sport index was normally distributed as assessed by Shapiro-Wilk's Test (*p*>.05), a Pearson correlation was also conducted. Results from the Pearson correlation also found a statistically significant relationship between social adjustment and PA participation, more specifically the sport index (*r*=.48, *n*=21, *p*=.031). An *r* value of .48 indicates a positive relationship with a moderate effect size. Social adjustment was not statistically significantly correlated with the leisure index (*p*>.05) or the TSK (*p* >.05).

Adjustment to Limitation. Data collected for adjustment to limitation were normally distributed, as assessed by the Shapiro-Wilk's Test (*p*>.05). For this reason, a Pearson correlation was conducted to compare adjustment to limitation to the sport index, the leisure index, and the TSK. Adjustment to limitation had a statistically significant correlation with both PA participation measures, the sport index (*r*=.58, *n*=21, *p*=.005), and the leisure index (*r*=.46, *n*=21, *p*=.037). An *r* value of .58 indicates a positive relationship with a large effect size. An *r* value of .46 indicates a positive relationship with a moderate effect size. Adjustment to limitation also showed a significant correlation with the TSK (*r*=-.67, *n*=21, *p*=.000). An *r* value of .67 indicates a negative relationship with a large effect size.

Activity Restriction. Data collected for activity restriction were normally distributed, as assessed by the Shapiro-Wilk's Test (*p*>.05). For this reason, a Pearson correlation was conducted to compare activity restriction to the sport index, the leisure index, and the TSK. Activity restriction had a statistically significant correlation with both the sport index (*r*=-.70, *n*=21, *p*=.000), and the leisure index (*r*=-.64, *n*=21, *p*=. 002). An *r* value of -.70 indicates a negative relationship with a large effect size, while an *r* value of -.64 indicates a negative relationship with a large effect size. Activity restriction was also statistically significantly correlated with the TSK (r=.63, n=21, p=.002), indicating a positive relationship with a large effect size.

Aesthetic Satisfaction. Data collected for aesthetic satisfaction were non-normally distributed, as assessed by the Shapiro-Wilk's Test (p<.01). For this reason, a Spearman correlation was used to analyze the data. No statistically significant relationships between aesthetic satisfaction and PA participation or PA avoidance were detected using The Spearman correlation (p>.05). As data for several TAPES measures were normally distributed, a Pearson correlation was also conducted. No statistically significant relationships between aesthetic satisfaction and PA participation (the sport or leisure indices) or PA avoidance (the TSK) were detected using The Pearson correlation (p>.05).

Functional Satisfaction. Data collected for functional satisfaction were normally distributed, as assessed by the Shapiro-Wilk's Test (p>.05). For this reason, a Pearson correlation was conducted to compare functional satisfaction to the sport and leisure indices, as well as the TSK. Functional satisfaction revealed a statistically significant correlation with both the sport index (r=.66, n=21, p=.000), and the leisure index (r=.56, n=21, p=.009). An r value of .66 indicates a positive relationship with a large effect size, while an r value of .56 indicates a positive relationship with a large effect size. Activity restriction was also statistically significantly correlated with the TSK scale (r=-.49, n=21, p= .024). An r value of .49 indicates a negative relationship with a moderate to large effect size.

Table 5.
Pearson Product correlation between Adjustment to Limitation, Activity Restriction, and Functional Satisfaction and the Sport Index, the Leisure Index, and the TSK.

	Adjustment to Limitation	Activity Restriction	Functional Satisfaction
Sport Index	(r= .57, n= 21, p=.007)	(r= -.67, n= 21, p=.000)	(r= .60, n= 21, p=.002)
Leisure Index	(r= .39, n= 21, p=.079)	(r= -.62, n= 21, p=.003)	(r= .53, n= 21, p=.014)
TSK	(r= -.71, n= 21, p=.000)	(r= .62, n= 21, p=.002)	(r= -.56, n= 21, p=.009)

Other Significant Relationships

Correlations between the variables from the TAPES subscales, the ABC, the TSK, and the BAQ and the demographic information collected were completed using a Pearson correlation for normally distributed variables and a Spearman correlation for non-normally distributed variables.

Data collected for PA participation were normally distributed, as assessed by the Shapiro-Wilk's Test (p >.05). For this reason, a Pearson correlation was conducted to compare PA participation to PA avoidance, specifically the sport index showed a statistically significant correlation with the avoidance of PA (r=-.63, n=21, p=.002). An r value of -.63 indicates a negative relationship with a large effect size. The leisure index was not statistically significantly correlated with PA avoidance (p>.05).

Data collected for participant age were non-normally distributed, as assessed by the Shapiro-Wilk's Test (p >.05). For this reason, a Spearman correlation was conducted to compare age with the variables from the TAPES subscales, the ABC, the TSK, the BAQ, and the demographic information. Age was not significantly correlated with any variables in this study (p>.05).

Chapter Five: Discussion

The purpose of this study was to explore the relationship between balance confidence and the physical and psychosocial effects of TTA and how this related to PA participation and avoidance habits. Specifically, we were interested in determining the relationship between balance confidence and participation in PA and balance confidence and avoidance of PA. We were also interested in investigating the relationship between the physical and psychosocial adaptation to unilateral TTA and participation in or avoidance of PA.

Results from this study support previous findings, where balance confidence is related to an individual with TTA's decision to participate in PA as those with higher balance confidence were found to engage in more sport PA. Similarly, previous research has shown that a lack of balance confidence should contribute to PA avoidance habits, however, the results of this study do not support those findings as no relationship between balance confidence and PA avoidance was detected. Additionally, the results indicate that the physical and psychosocial effects of TTA are significantly related to both PA participation and avoidance habits. Specifically, individuals who feel greater activity restriction, less adjustment to their limitation, and less functional satisfaction engage in PA at lower rates and more frequently actively avoid PA. Greater social adjustment was also related to greater participation in sport. Worse general adjustment to their amputation was related to the avoidance of leisure PA. These results with respect to the research questions will be discussed in the context of the literature below. Other interesting relationships that do not pertain to our research question will also be discussed below.

Balance Confidence and Physical Activity Participation and Avoidance

Balance Confidence and Physical Activity Participation

A statistically significant large positive correlation was detected between balance confidence and the sport index from the BAQ meaning that those with higher balance confidence scores also seemed to have a higher rate of sports participation. These findings support the work of Mandel et al. (2016) and Miller et al. (2001) who found that balance confidence may contribute to an individual's decision to engage in PA. This finding is consistent with how active participants reported that they were. The average balance confidence score in this study was 68.3 (25.56) indicating an average of medium balance abilities for the sample. Sports active participants participated in an average of 10.4 (7.95) hours of sport each week which is over four times the national recommendation for weekly PA in Canada (Ross et al., 2020). Participants also reported engaging in sports an average of 9.8 (2.86) months per year. A potential explanation for why the sports active participants in this group were more active compared to the rest of the group, and the Canadian national recommendations, can be had by examining the gatekeepers who helped recruit participants. The national para hockey team and the Canadian Amputee Hockey Committee are both athletic organizations for individuals with disabilities. The constituency of these organizations consists of many high-performance athletes and Paralympians. Although it is impossible to determine due to the anonymity of the survey, it is likely that the high-performance nature of the members of these groups is responsible for the high rates of sport participation. These results indicate that the participants in the study who participated in sport, did so very frequently. This finding between those who participated in sport and those who did not, accentuates the relationship between balance confidence and the sport index. The intensity these sports are performed at, however, is just as important as the frequency of performance when examining the sports participation habits. Although the frequency of sport participation was high for the sport's active participants, the intensity was not always so. Some participants reported participating in high intensity sports such as CrossFit, downhill skiing, and hockey, however, the majority reported participating in lower intensity sports such as walking, wheelchair curling, golfing, and fishing.

No statistically significant correlation was detected between balance confidence and the leisure index. When examining the results from the Spearman correlation, a non-significant positive correlation with a moderate effect size was present (p=.185). Due to the lack of statistical significance, it would not be appropriate to draw conclusions from these results. These results, however, do indicate that a larger sample size could reveal a significant relationship between balance confidence and the leisure index. The lack of significant correlation between balance confidence and the leisure index can possibly be explained by examining the leisure index. Although the BAQ has been validated for populations of adult women with hip disorders, has been used with populations who have type 2 diabetes, peripheral neuropathy and foot deformities, and used to help validate a continuous ambulatory activity monitor for people with LEA caused by malignancy, the BAQ has not been previously validated for use in a TTA population (Adeniyi et al., 2015; Ono et al., 2007; Van Dam et al., 2001). As a result, it is possible that characteristics unique to the TTA population could affect leisure activity, making this index less applicable. The leisure index consists of four questions: during leisure time I watch television, during leisure time I walk, and during leisure time I cycle (never, seldom, sometimes, often and very often) and how many minutes per day do you walk and/or cycle? (<5 minutes, 5-15 minutes, 15-30 minutes, 30-45 minutes, and >45 minutes). These questions may not be appropriate for populations with TTA as only 4 to 48% of people with LEA choose to cycle as a method of transportation, recreation, or sport (Poonsiri et al., 2018). When recreational cycling was examined, veterans with transfemoral and TTA participated in cycling at similar rates (11%; Littman et al., 2014). In this study, 80.9% of participants reported never cycling and the other 19.1% seldomly cycled. In addition to the low cycling rates in the TTA population, cycling for people with TTA can require specialized equipment and knowledge such as a special prosthetic foot and an appropriate crank length on the bicycle (Poonsiri et al., 2018). As this study was specific to people with TTA living in Canada, Canada's climate may have also affected cycling and leisure PA participation rates. Participation in leisure time PA in Canada has been shown to be 86% more likely in the summer than in the winter (Merchant et al., 2007). Canada's cold climate can make cycling, walking, or any form of active commute significantly more difficult to downright impossible depending on how much snow and ice the participants' region receives during the winter months.

Another potential explanation for the lack of correlation between balance confidence and the leisure index may lie in the differences between sport and leisure activities. Bragaru et al. reported that people with LEA "who are more aware of the risks (associated with PA; e.g., injuries, costs, problematic transport, etc.) than the benefits (e.g., physical and psycho-social well-being) may be more likely to be non-athletes, while the individuals with LEA who are more aware of what they may lose (e.g., physical and psychosocial well-being) if they do not participate are more likely to be athletes," (2013, p. 8). Perhaps people with TTA and high balance confidence modify their PA choices to maximize the benefits of PA while minimizing the potential consequences. Burger and Marincek (1997) found that in people younger than 51 years of age, before amputation, cycling was the most preferred leisure time activity. After amputation however, cycling fell to the tenth most preferred leisure time activity, indicating a significant change in leisure time activity preference (Burger & Marincek, 1997). Additionally, sports provide a host of benefits outside of the physical including fun, socialization, coaching, and a controlled environment to participate in (Bragaru et al., 2013). As a result, when selecting an activity to participate in people with TTA may be more inclined to choose a formal sport than a leisure activity if they have a high level of balance confidence. Alternatively, the mean balance confidence score was 68.3 (25.56), indicating a moderate level of balance confidence. As a result, the sample recruited for this study may have found that leisure activities were easy enough to complete regardless of balance confidence abilities.

Balance Confidence and Physical Activity Avoidance

Contrary to Mandel et al.'s (2016) prediction, our data did not reveal a relationship between balance confidence and PA avoidance habits. The lack of correlation with balance confidence and PA avoidance may be due to the design of the outcome measures. The ABC measures balance confidence and balance confidence refers specifically to an individual's perceived ability not to fall during a given task (Mandel et al., 2016). The TSK alternatively, assesses kinesiophobia, a general fear of movement. This fear could be caused not just by falling, but by any pain brought on by PA. In our study, 61.9% of the participants surveyed reported experiencing stump pain and 61.9% reported experiencing phantom limb pain. In addition, 57.1% of participants reported living with other medical problems such as low back pain, friction blisters, and sore spots caused by the interaction between the residual and prosthetic limb. These other sources of pain may have influenced PA avoidance more than balance confidence and the fear of pain from falling.

Stump pain, phantom limb pain, and chronic pain in general have each been shown to impact participation in PA (Bragaru et al., 2013). Phantom and residual limb pain have also been shown to cause people with LEA to present with increased anxiety and depression symptoms (Bhutani et al., 2016). This is especially concerning as a moderate to large correlation was found between the cause of amputation and phantom limb pain. These findings support the work of Ephraim et al. (2003) who found that PAD related amputation resulted in phantom limb pain in 82.9% of participants. Traumatic amputation resulted in phantom limb pain in 81.2% of participants, and cancer related amputation resulted in phantom limb pain in 73.0% of participants (Ephraim et al., 2003). In comparison, only 19.7% of participants with congenital amputation experienced a phantom limb of any kind. As a result, phantom limb pain is rarely reported in people with congenital amputation (Melzack et al., 1997).

Physical and Psychosocial Adaptation to TTA and PA Participation and Avoidance

Social Adjustment and Physical Activity Participation

In terms of the social adjustment of TTA, there was a large positive statistically significant correlation between social adjustment and the sport index from the BAQ. This indicated a relationship between higher social adjustment scores and higher rates of sport participation. These findings are in line with previous research by Wadey and Day (2018). The themes revealed by Wadey and Day (2018) provided insights into the relationship between social adjustment and PA participation. Using thematic interviews, distinct PA disengagement and engagement strategies were revealed, and these themes reflected how participants presented themselves. Participants with presumably low social adjustment disengaged from PA by hiding their prosthetic limb, spending more time at home, and not engaging with the public. Alternatively, participants with presumably high social adjustment presented themselves with open and engaging body language, showing off their prosthetic, and participating in humor and group conversation (Wadey & Day, 2018). Although causality cannot be determined using correlational data, findings from our study strengthen the evidence for a relationship between social adjustment and participation in PA.

Adjustment to Limitation, Activity Restriction, and Functional Satisfaction

Adjustment to limitation, activity restriction, and functional satisfaction were all significantly correlated with the sport index, the leisure index, and the TSK. This indicates that people with TTA who are more well-adjusted participate in higher rates of PA, while those who are less well-adjusted are more likely to actively avoid PA. The large positive relationship with adjustment to limitation and functional satisfaction between both the sport and leisure indices indicates when adjustment to limitation and functional satisfaction scores are lower, sports participation is higher. Similarly, the large negative correlation with activity restriction and the sport and leisure indices indicates low levels of PA participation when activity restriction is high and high levels of PA participation when activity restriction is low. The large negative relationship with adjustment to limitation and functional satisfaction and the TSK indicates when adjustment to limitation and functional satisfaction is lower, TSK scores are higher. These relationships were not surprising as adjustment to limitation, activity restriction, and functional satisfaction all showed large correlations with each other. People with TTA who felt more adjusted to their limitations, felt less restriction during activities, and felt overall more satisfied with the function of their prosthetic limb reported participating in sport and leisure PA more and avoiding PA less than those with worse adjustment to their limitation, greater activity restriction, and less functional satisfaction.

Other Significant Relationships and Findings

To add confirmatory data to the validity of the TSK scale, we found that the sport index was found to be negatively correlated with the TSK while the leisure index was not correlated with the TSK. These findings indicated individuals who participated in sports were less likely to avoid PA than those who do not participate in sport. Participation in leisure time PA was not related to the avoidance of PA. These results are in line with results from knee osteoarthritis populations, where the TSK has shown a negative correlation with PA participation (Selçuk & Karakoyun, 2020). The lack of correlation with the leisure index may be related to the leisure index of the BAQ being a poor fit for the TTA population, or leisure activities being associated with less fear of movement than sport activities.

Recommendations for PA engagement for those with TTA

Based on the findings of this research project there are several recommendations that can be made for those with TTA to help them engage in PA. Significant relationships with PA participation were found with balance confidence and several factors related to adaption to TTA (social adjustment, adjustment to limitation, activity restriction, and functional satisfaction). As the goal is to increase PA participation in people with TTA, regardless of the causality of these relationships, efforts should be made to improve balance confidence and the physical and psychosocial adaptation to TTA. Previous research has shown that balance confidence can be improved by using training interventions like those used by Kaufman et al. (2014) and Liu-Ambrose et al. (2004; discussed in the Balance Confidence section of Chapter Two). Healthcare practitioners and individuals with TTA should incorporate similar training protocols as a part of the rehabilitation process to help improve their balance confidence and, in turn, their PA participation.

No previous research found during a review of the available literature examined interventions aimed at improving physical and psychosocial adaptation to TTA. Poor physical and psychosocial adaptation to TTA, however, has been associated with multiple psychosocial domains including depression, anxiety, and body image issues (Luthi et al., 2020). Until such a time where interventions that specifically aim to improve physical and psychosocial adaptation to TTA are developed, healthcare practitioners and individuals with TTA should incorporate interventions that have been shown to improve psychosocial wellbeing in the able-bodied populations as a part of the rehabilitation process. This could contribute to increased engagement in PA for those with TTA.

Future Research

As the current study was the first to examine the relationship between balance confidence and PA avoidance, more research in needed to determine if there is indeed no relationship between balance confidence and PA avoidance, or if this study did not have enough participants to create an accurate picture of these constructs and amputation in Canada. Either way, future research should recruit a larger sample size to produce more results with greater statistical power. If a large enough sample size can be recruited, designing a study that utilizes multiple regression would be ideal to help understand and identify the interconnections between people with TTA and their PA participation and avoidance habits, as well as causality in the significant relationships detected in this study.

Regardless of the causality of the relationships detected in this study higher rates of balance confidence and better physical and psychosocial adaptation to amputation scores are related to greater rates of PA participation. Lower physical and psychosocial adaptation to amputation scores are also related to greater rates of PA avoidance. Furthermore, previous research has identified several interventions that improve balance confidence and mental health. Future research should investigate how to implement these methods on a large scale in order to maximize the number of people these interventions are assisting. Future research should also examine how to improve physical and mental health, specifically in the context of physical and psychosocial adaptation to amputation.

Future research should also examine gender differences when examining PA participation and avoidance habits as women are chronically underrepresented in amputation research (Cimino et al., 2021). TTA. Factors that were not explored in this study should also be examined including the age of amputation and pre-amputation PA levels and how this relates to PA avoidance habits.

Limitations to Study Design and Interpretation

As the survey was completed anonymously, electronically, and remotely, there was no way for the student researcher to ensure all questions were entirely completed before submission. Additionally, participants were under no obligation to answer each question. If a participant chose to skip a question, they were free to do so. This resulted in missing data in the ABC section, as well as in the age and social adjustment sections of the TAPES.

All responses to the ABC were still considered valid as internal consistency is not appreciably decreased with the deletion of four or less of the 16 items (Myers et al., 1998). No ABC response contained more than four blank responses; therefore, all responses were considered valid, mitigating the impact of missing data would have had on the ABC section.

When considering the interpretation and generalizability of the results of this study, several limitations must be addressed. Firstly, difficulties in participant recruitment resulted in the sample size of this study (21) falling far below the a priori power analysis desired sample size (67). Due to the lack of sample size, any correlations where $r<.52$ did not achieve the recommended power=.8, these correlations should be interpreted with caution. The difficulties with recruitment could be attributed to the COVID-19 pandemic and attempting to recruit participants electronically. The COVID-19 pandemic limited the number of patients healthcare practitioners, such as prosthetists, are seeing at their offices. The reduced number of patients visiting clinics reduced the number of potential participants that viewed the recruitment poster. A longer recruitment window could have been used to garner more participants, however previous delays related to the COVID-19 pandemic and financial constraints made this not feasible.

The COVID-19 pandemic may have also impacted PA participation rates due to the restrictions caused by the pandemic such as reduced building capacities, facility closures, and program cancelation. Additionally, the chance of contracting COVID-19 adds a psychological barrier that may reduce the chances participants would participate in PA in spite of these restrictions.

As this was an exploratory study and there were preexisting difficulties with recruiting, analysis did not control for demographic variables such as age, gender, sport participation, or cause of amputation. As a result, each of these factors could influence the outcome measures selected for the study. To mitigate the impact demographic variables had on the results, the demographic variables were examined for relationships with the variables from the TAPES, ABC, BAQ, and, TSK. Due to the limited sample size, this study did not have the required power to detect small and moderate correlations.

The statistical design of this study relied upon bivariate correlations and as such causality cannot be determined from any of the results. Another impact of the statistical design of this study is the likelihood of a type I error. This study correlated 10 variables (one from the ABC, six from the TAPES, two from the BAQ, and one from the TSK) with each other and with the 10 demographic variables collected. As the demographic variables were not controlled, correlations between outcome measures and the demographic variables were performed to mitigate the potential impact a significant relationship between the outcome measures and the demographic variables could create. Although statistically significant results were found, they should be interpreted with caution as the chance for error is high with the high number of correlations being performed. To mitigate the impact a potential type I error may have on the results, all significant relationships discussed were supported by previous literature or the guiding question.

Finally, non-response bias is another potential limitation of this study. Non-response bias occurs when participants refuse to participate in a study or drop out early. These non-responders may be systematically different from those who choose to participate, resulting in the study portraying a non-representative sample of the actual population (Cheung et al., 2017). The amount of non-response in this study was unknown as it was impossible to determine how many potential participants chose not to participate. Fortunately, no participants dropped out once starting the study.

Conclusion

The purpose of this study was to explore the relationship between balance confidence and the physical and psychosocial effects of TTA and how this related to PA participation and avoidance habits. This study built on and supported previous work examining balance confidence and PA participation in populations with TTA. This study also added to the limited literature examining PA participation and avoidance habits in people with TTA.

The results of this study were in line with previous studies, in that balance confidence was significantly related to PA participation, specifically sport. This study, however, did not support the theory that balance confidence was related to PA avoidance. Additionally, there was a relationship between the physical and psychosocial adaptation to unilateral TTA and both participation in and avoidance of PA. These results indicate that in order to increase PA engagement and participation, healthcare practitioners should design rehabilitation programs for people with TTA that focus on balance confidence training and facilitating a positive physical and psychosocial adaptation following TTA.

TTA is a complex and life changing event and adaptation to this event is an ongoing process. Adaptations such as adjusting to the limitation, activity restriction, as well as satisfaction with the function of the prosthetic are all related to PA participation and avoidance habits. Participating in sports is also related to higher social adjustment scores. Regardless of the causality of these relationships, participating in PA, specifically sport has physical and psychosocial benefits that cannot be undervalued.

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Appendix A

The Trinity Amputation and Prosthesis Experience Scales- R (TAPES)

This is a questionnaire designed to investigate different aspects of having a prosthesis. Please answer every item as honestly as you can. There are no right or wrong answers. Your responses will remain confidential.

Section 1- Part 1

Below are written a series of statements concerning the wearing of a prosthesis. Please read through each statement carefully. Then select the box beside the most appropriate statement, which shows how strongly you agree or disagree with it.

I have adjusted to having a prosthesis

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree
- Not Applicable

As time goes by, I accept my prosthesis more

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree

I feel that I have dealt successfully with this trauma in my life

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree
- Not Applicable

Although I have a prosthesis, my life is full

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree
- Not Applicable

I have gotten used to wearing a prosthesis

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree
- Not Applicable

I don't care if somebody looks at my prosthesis

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree
- Not Applicable

I find it easy to talk about my prosthesis

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree
- Not Applicable

I don't mind people asking about my prosthesis

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree
- Not Applicable

I find it easy to talk about my limb loss in conversation

- Strongly Disagree
- Disagree
- Agree

- Strongly Agree
- Not Applicable

I don't care if somebody notices that I am limping

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree
- Not Applicable

A prosthesis interferes with the ability to do my work

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree
- Not Applicable

Having a prosthesis makes me more dependent on others than I would like to be

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree
- Not Applicable

Having a prosthesis limits the kind of work that I can do

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree
- Not Applicable

Being an amputee means that I can't do what I want to do

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree
- Not Applicable

Having a prosthesis limits the amount of work that I can do

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree
- Not Applicable

Section 1- Part 2

The following questions are about activities you might do during a typical day. Does having a prosthesis limit you in these activities? If so, how much? Please select the appropriate box.

The following questions are about activities you might do during a typical day.

Does having a prosthesis limit you in these activities? If so, how much? Please select the appropriate box.

Vigorous activities, such as running, lifting heavy objects, or participating in strenuous sports

- Yes, limited a lot
- Limited a little
- No, not limited at all

Climbing several flights of stair

- Yes, limited a lot
- Limited a little
- No, not limited at all

Running for a bus

- Yes, limited a lot
- Limited a little
- No, not limited at all

Sports and recreation

- Yes, limited a lot
- Limited a little
- No, not limited at all

Climbing one flight of stairs

- Yes, limited a lot
- Limited a little
- No, not limited at all

Walking more than a mile

- Yes, limited a lot
- Limited a little
- No, not limited at all

Walking half a mile

- Yes, limited a lot
- Limited a little
- No, not limited at all

Walking 100 metres

- Yes, limited a lot
- Limited a little
- No, not limited at all

Working on hobbies

- Yes, limited a lot
- Limited a little
- No, not limited at all

Going to work

- Yes, limited a lot
- Limited a little
- No, not limited at all
- Not Applicable

Section 1- Part 3

Please tick the box that represents the extent to which you are satisfied or dissatisfied with each of the different aspects of your prosthesis:

Color

- Not Satisfied
- Satisfied
- Very Satisfied

Shape

- Not Satisfied
- Satisfied
- Very Satisfied

Appearance

- Not Satisfied
- Satisfied
- Very Satisfied

Weight

- Not Satisfied
- Satisfied
- Very Satisfied

Usefulness

- Not Satisfied
- Satisfied
- Very Satisfied

Reliability

- Not Satisfied
- Satisfied

- Very Satisfied

Fit

- Not Satisfied
- Satisfied
- Very Satisfied

Comfort

- Not Satisfied
- Satisfied
- Very Satisfied

Please select the number (0-10) that best describes how satisfied you are with your prosthesis?

Not at all Satisfied 1 2 3 4 5 6 7 8 9 10 Very Satisfied

Section 2- Part 1

For the following questions, please select the appropriate boxes

1) On average, how many hours a day do you wear your prosthesis?

____

2) In general, would you say your health is:

- Very Poor

- Poor

- Fair

- Good

- Very Good

3) In general, would you say your physical capabilities are:

- Very Poor

- Poor

- Fair

- Good

- Very Good

4 a) Do you experience residual limb (stump) pain (pain in the remaining part of your amputated limb)?

No (If no, skip to question 5)

Yes (If yes, answer part (b), (c), (d) and (e))

Question 4: Continued

b) During the last week, how many times have you experienced stump pain?

_____

c) How long, on average, did each episode of pain last?

______

d) Please indicate, the average level of stump pain experienced during the last week on the scale below by ticking the appropriate box:

Mild 1 2 3 4 5 Excruciating

e) How much did stump pain interfere with your normal lifestyle (eg. work, social and family activities) during the last week?

Not at All 1 2 3 4 5 A Lot

5 a) Do you experience phantom limb pain (pain in the part of the limb which was amputated)?

No (If no, skip to question 6)

Yes (If yes, answer part (b), (c), (d) and (e))

b) During the last week, how many times have you experienced phantom limb pain?

c) How long, on average, did each episode of pain last?

d) Please indicate, the average level of stump pain experienced during the last week on the scale below by ticking the appropriate box:

Mild 1 2 3 4 5 Excruciating

e) How much did stump pain interfere with your normal lifestyle (eg. work, social and family activities) during the last week?

Not at All 1 2 3 4 5 A Lot

6 a) Do you experience any other medical problems apart from stump pain or phantom limb pain?

No (skip the rest of question 6)

Yes (If yes, answer part (b), (c), (d) and (e), (f), and (g))

b) Please specify what problems you experience

c) During the last week, how many times have you suffered from these medical problems?

d) How long, on average, did each problem last?

e) Please indicate the level of pain experienced as a result of these problems during the last week on the scale below by ticking the appropriate box:

Mild 1 2 3 4 5 Excruciating

f) How much did these medical problems interfere with your normal lifestyle (eg. work, social and family activities) during the last week?

Not at All 1 2 3 4 5 A Lot

g) Do you experience any other pain that you have not previously mentioned? If yes, please specify

Did you complete this questionnaire on your own or with assistance?

- On your own
- With assistance

Appendix B

The Activities-Specific Balance Confidence Questionnaire

For each of the following activities, please indicate your level of confidence in doing the activity without losing your balance or becoming unsteady from choosing one of the percentage points on the scale from 0% to 100%. If you do not currently do the activity in question, try and imagine how confident you would be if you had to do the activity. If you normally use a walking aid to do the activity or hold on to someone, rate your confidence as if you were using these supports.

How confident are you that you will not lose your balance or become unsteady when you:

Walk around the house?

Walk up or down the stairs?

Bend over and pick up a slipper from the floor at the front of a cupboard?

Reach for a small tin of food from a shelf at eye level?

Stand on your tip toes and reach for something above your head?

Stand on a chair and reach for something?

Sweep the floor?

Walk outside the house to a parked car?

Get into or out of a car?

Walk across a car park to the shops?

Walk up or down a ramp?

Walk in a crowded shopping center where people walk past you quickly?

Are bumped into by people as you walk through the shopping center?

Step onto or off an escalator while holding onto the handrail?

Step onto or off an escalator while holding onto parcels such that you cannot hold onto the handrail?

Appendix C

The Baecke Questionnaire

The Baecke Questionnaire- Work Index

For this questionnaire activities are scored from 1 to 5. A score of 5 always indicates the highest activity response and a score of always 1 indicates the least activity response. The section is designed to collect data about your physical activity habits during your work time.

What is your main occupation?

At work I sit:

Never 1 2 3 4 5 Always

At work I stand:

Never 1 2 3 4 5 Always

At work I walk:

Never 1 2 3 4 5 Always

At work I lift heavy loads:

Never 1 2 3 4 5 Always

After working I am tired:

Never 1 2 3 4 5 Very Often

At work I sweat:

Never 1 2 3 4 5 Very Often

In comparison to others my own age I think my work is physically:

Much lighter 1 2 3 4 5 Much heavier

Baecke Questionnaire- Leisure Index

The section is designed to collect data about your physical activity habits during your leisure time.

During leisure time I watch television:

Never 1 2 3 4 5 Very Often

During leisure time I walk:

Never 1 2 3 4 5 Very Often

During leisure time I cycle:

Never 1 2 3 4 5 Very Often

How many minutes do you walk and/or cycle per day to and from work, school, and shopping?

<5 minutes

5-15 minutes

15-30 minutes

30-45 minutes

>45 minutes

Baecke Questionnaire- Sport Index

The section is designed to collect data about your physical activity habits while playing sports.

Do you play sports? *

Yes

No

In comparison with others of my own age I think my physical activity during leisure time is:

Much less 1 2 3 4 5 Much more

During leisure time I sweat:

Never 1 2 3 4 5 Very Often

During leisure time I play sport:

Never 1 2 3 4 5 Very Often

Primary Sport

This section of the study has been designed to collect data about your most frequently played sport.

What sport do you play most frequently?

How many hours do you play a week?

How many months do you play in a year?

Do you play a second sport? *

- Yes
- No

Second Sport

This section of the study has been designed to collect data about your second sport.

What sport do you play second most frequently?

How many hours do you play a week?

How many months do you play in a year?

Appendix D

The Tampa Scale for Kinesiophobia

I'm afraid that I might injury myself if I exercise:

Strongly disagree 1 2 3 4 Strongly agree

If I were to try to overcome it, my pain would increase:

Strongly disagree 1 2 3 4 Strongly agree

My body is telling me I have something dangerously wrong:

Strongly disagree 1 2 3 4 Strongly agree

My pain would probably be relieved if I were to exercise:

Strongly disagree 1 2 3 4 Strongly agree

People aren't taking my medical condition seriously enough:

Strongly disagree 1 2 3 4 Strongly agree

My accident has put my body at risk for the rest of my life:

Strongly disagree 1 2 3 4 Strongly agree

Pain always means I have injured my body:

Strongly disagree 1 2 3 4 Strongly agree

Just because something aggravates my pain does not mean it is dangerous:

Strongly disagree 1 2 3 4 Strongly agree

I am afraid that I might injure myself accidentally:

Strongly disagree 1 2 3 4 Strongly agree

Simply being careful that I do not make any unnecessary movements is the safest thing I can do to prevent my pain from worsening:

Strongly disagree 1 2 3 4 Strongly agree

I wouldn't have this much pain if there weren't something potentially dangerous going on in my body:

Strongly disagree 1 2 3 4 Strongly agree

Although my condition is painful, I would be better off if I were physically active:

Strongly disagree 1 2 3 4 Strongly agree

Pain lets me know when to stop exercising so that I don't injure myself:

Strongly disagree 1 2 3 4 Strongly agree

It's really not safe for a person with a condition like mine to be physically active:

Strongly disagree 1 2 3 4 Strongly agree

I can't do all the things normal people do because it's too easy for me to get injured:

Strongly disagree 1 2 3 4 Strongly agree

Even though something is causing me a lot of pain, I don't think it's actually dangerous:

Strongly disagree 1 2 3 4 Strongly agree

No one should have to exercise when he/she is in pain:

Strongly disagree 1 2 3 4 Strongly agree

Appendix E

All correlations between outcome variables performed

Table 6.
Pearson Product correlation results for intercorrelations between outcome measures.

Measure	1	2**	3	4**	5**	6	7**	8**	9**	10**
1. **ABC Score**	1.00									
	--									
TAPES Scores										
2. General Adjustment**	.16	1.00								
	.489	--								
3. Social Adjustment	.17	.06	1.00							
	.483	.804	--							
4. Adjustment to Limitation**	.13	.69*	.41	1.00						
	.568	.000	.073	--						
5. Activity Restriction **	-.29	-.65*	-.44	-.83*	1.00					
	.207	.002	.053	.000	--					
6. Aesthetic Satisfaction	.10	.36	.65*	.50*	-.55*	1.00				
	.656	.114	.002	.023	.009	--				
7. Functional Satisfaction**	.13	.52*	.42	.54*	-.74*	.54*	1.00			
	.569	.016	.065	.012	.000	.011	--			
BAQ Scores										
8. Sport Index**	.33	.34	.48*	.58*	-.70*	.31	.66*	1.00		
	.143	.138	.031	.005	.000	.165	.001	--		
9. Leisure Index**	.18	.26	.26	.46*	-.64*	.21	.56*	.61*	1.00	
	.434	.247	.272	.037	.002	.355	.009	.004	--	
10. **TSK Score***	-.10	-.54*	-.22	-.67*	.63*	-.27	-.49*	-.63*	-0.40	1.00
	.657	.012	.342	.001	.002	.231	.024	.002	.070	--

Note. Values are listed for each variable as effect size (*r*; top) and significance (*p;* bottom).

*Indicates a significant relationship **Indicates values were normally distributed

Table 7.

Spearman correlation results for intercorrelations between outcome measures.

Measure	1	2**	3	4**	5**	6	7**	8**	9**	10**
1. **ABC Score**	1.00									
	--									
TAPES Scores										
2. General Adjustment**	.23	1.00								
	.323	--								
3. Social Adjustment	.33	.13	1.00							
	.154	.584	--							
4. Adjustment to Limitation**	.38	.72*	.30	1.00						
	.093	.000	.204	--						
5. Activity Restriction **	-.41	-.68*	-.41	-.80*	1.00					
	.068	.001	.076	.000	--					
6. Aesthetic Satisfaction	.26	.40	.58*	.44*	-.59*	1.00				
	.249	.071	.007	.045	.005	--				
7. Functional Satisfaction**	.26	.54*	.39	.50*	-.74*	.59*	1.00			
	.255	.011	.090	.021	.000	.005	--			
BAQ Scores										
8. Sport Index**	.48*	.25	.46*	.57*	-.67*	.32	.65*	1.00		
	.029	.281	.042	.007	.000	.156	.002	--		
9. Leisure Index**	.30	.23	.32	.39	-.62*	.24	.53*	.64*	1.00	
	.185	.325	.172	.079	.003	.293	.014	.002	--	
10. **TSK Score****	-.33	-.50*	-.20	-.71*	.62*	-.36	-.56*	-.47*	-.32	1.00
	.141	.021	.402	.000	.003	.110	.009	.031	.162	--

Note. Values are listed for each variable as effect size (r_s; top) and significance (p; bottom).

*Indicates a significant relationship **Indicates values were non-normally distributed

Table 8.
Spearman correlation results for intercorrelations between demographic information.

	1	2	3	4	5	6	7	8	9	10
1. Gender	1.00					0.39	-0.06			
	--					0.08	0.79			
2. Ethnicity	-.28	1.00				-.453*	0.16			
	.211	--				0.04	0.48			
3. Age	-.09	-.24	1.00			0.05	0.01			
	.720	.310	--			0.85	0.95			
4. Province	-.04	.16	-.30	1.00		0.29	0.01			
	.853	.492	.196	--		0.21	0.98			
5. Time Since Amputation	-.32	.32	-.06	-.02	1.00	-.473*	.574**			
	.158	.155	.808	.930	--	0.03	0.01			
6. Cause of Amputation	.39	-.45*	.05	.29	-.47*	1.00	0.08			
	.078	.039	.848	.206	.030	--	0.74			
7. Time with Current Prosthetic	-.06	.16	.01	.01	.57*	.08	1.00			
	.793	.485	.954	.980	.007	.741	--			
8. Stump Pain	.16	-.24	.25	-.11	.19	.02	.23	1.00		
	.497	.296	.295	.626	.399	.942	.319	--		
9. Phantom Limb Pain	-.11	.32	-.11	-.36	.34	-.43*	-.04	.19	1.00	
	.642	.159	.646	.112	.131	.048	.861	.404	--	
10. Other Chronic Pain	.41	-.22	.33	.31	-.22	.43	-.10	.11	-.28	1.00
	.062	.334	.157	.166	.332	.053	.653	.625	.214	--

Note. Values are listed for each variable as effect size (r_s; top) and significance (p; bottom). All results from the demographic information were non-normally distributed.

*Indicates a significant relationship

Table 9.

Pearson Product correlation results for correlations between outcome measures and demographic information.

	Gender	Ethnicity	Age	Province	Time Since Amputation	Cause of Amputation	Time with Current Prosthetic	Stump Pain	Phantom Limb Pain	Other Chronic Pain
ABC Score	-.23	.03	-.06	-.13	-.03	.15	.29	-.17	-.47*	-.31
	.307	.886	.789	.583	.901	.514	.197	.469	.034	.177
TAPES Scores										
General	-.18	.19	-.15	-.57*	.00	-.05	-.05	-.14	.11	-.25
Adjustment**	.425	.421	.519	.007	.997	.820	.816	.556	.646	.272
Social	-.06	.23	-.16	.36	-.20	-.02	.21	-.30	-.16	.28
Adjustment	.786	.330	.524	.125	.393	.931	.377	.193	.493	.227
Adjustment to	-.36	.41	-.03	-.27	.15	-.21	.16	-.46*	.16	-.22
Limitation**	.107	.064	.903	.240	.514	.371	.493	.035	.487	.349
Activity	.27	-.27	-.02	.43	.14	.03	-.02	.54*	-.09	.20
Restriction **	.245	.237	.929	.051	.549	.887	.945	.011	.713	.386
Aesthetic	-.16	.23	-.42	.07	.02	.03	.20	-.07	.13	.00
Satisfaction	.480	.307	.063	.778	.920	.901	.387	.764	.586	.988
Functional	-.35	.27	.08	-.36	-.04	-.18	-.06	-.45*	.29	-.17
Satisfaction**	.120	.233	.732	.108	.856	.435	.794	.042	.200	.470
BAQ Scores										
Sport Index**	-.08	.29	-.02	-.25	-.18	-.10	.03	-.70*	-.12	-.09
	.715	.208	.950	.284	.442	.676	.897	.000	.600	.688
Leisure	-.39	.22	.40	-.32	-.11	.01	-.10	-.31	.06	-.13
Index**	.083	.332	.080	.162	.639	.958	.651	.169	.807	.566
	.280	.207	.416	.172	.480	.820	.881	.005	.845	.592
TSK Score**	.03	-.18	.06	.46*	.09	.06	-.11	.54*	.12	.22
	.902	.432	.790	.036	.684	.793	.625	.012	.596	.345

Note. Values are listed for each variable as effect size (r; top) and significance (p; bottom). All results from the demographic information were non-normally distributed.

*Indicates a significant relationship **Indicates values were normally distributed

Table 10.
Spearman correlation results for correlations between outcome measures and demographic information.

	Gender	Ethnicity	Age	Province	Time Since Amputation	Cause of Amputation	Time with Current Prosthetic	Stump Pain	Phantom Limb Pain	Other Chronic Pain
ABC Score	-.35	-.07	-.08	-.12	.07	.04	.30	-.33	-.51*	-.27
	.118	.765	.741	.609	.769	.879	.179	.141	.018	.236
TAPES Scores										
General	-.17	.22	-.34	-.38	.12	-.17	.08	-.11	.16	-.23
Adjustment**	.449	.341	.140	.094	.594	.451	.728	.646	.501	.310
Social	-.09	.28	-.01	.30	-.02	-.04	.17	-.26	-.13	.40
Adjustment	.721	.227	.962	.206	.926	.853	.469	.267	.597	.082
Adjustment to	-.35	.36	-.24	-.22	.24	-.30	.05	-.43	.09	-.31
Limitation**	.125	.108	.316	.336	.306	.187	.819	.051	.699	.169
Activity	.21	-.27	.25	.34	.01	.15	.13	.51*	-.07	.20
Restriction **	.355	.231	.298	.127	.951	.529	.567	.018	.780	.387
Aesthetic	-.25	.27	-.48*	.09	.10	-.07	-.01	-.11	.14	.00
Satisfaction	.270	.236	.032	.695	.651	.777	.979	.634	.557	1.000
Functional	-.25	.36	-.35	-.27	.04	-.27	-.15	-.51*	.27	-.27
Satisfaction**	.281	.108	.127	.239	.880	.237	.527	.020	.246	.240
BAQ Scores										
Sport Index**	-.13	.33	-.25	.02	-.05	-.07	.02	-.38	-.15	-.36
	.669	.191	.372	.749	.523	.464	.317	.001	.550	.581
Leisure Index**	-.10	.30	-.21	-.07	-.15	-.17	-.23	-.68*	-.14	-.13
	.160	.196	.414	.309	.636	.906	.727	.137	.972	.703
TSK Score**	-.24	.34	-.03	-.18	-.15	-.10	-.21	-.58*	-.06	-.17
	.817	.474	.541	.168	.884	.646	.897	.016	.780	.280

Note. Values are listed for each variable as effect size (r_s; top) and significance (p; bottom). All results from the demographic information were non-normally distributed.

*Indicates a significant relationship **Indicates values were normally distributed