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Physical Activity for the Treatment of Phantom Limb Pain

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Phantom limb pain (PLP) is a complex and multifactorial phenomenon whereby individuals with an amputation feel intermittent pain or discomfort where the limb used to be. Although there is no specific treatment for PLP, research suggests that participation in regular physical activity may reduce PLP symptoms. This study was designed to examine the relationship between PLP and regular physical activity. Nine lower-limb amputees (18 to 80 years) volunteered to participate in this study. Participants were recruited from online support groups and were invited to complete a Qualtrics survey. Questions regarding time since amputation, PLP symptoms, prior treatments and involvement in physical activity were asked. Most volunteers participated in some form of physical activity but noted they were either unsure or did not have a reduction in the duration of their PLP episodes. However, participation in regular physical activity did lead to a reduction in the intensity and frequency of PLP. Combining physical activity with other treatments did not alter the experience of PLP. These results indicate that health care providers (HCPs) should encourage patients with lower-limb amputations to participate in regular physical activity to maintain and promote physical health and as an intervention to reduce the intensity of PLP.

Keywords: *amputees, phantom limb pain, treatment, physical activity, exercise*

Introduction

Phantom limb pain (PLP) can be defined as pain or discomfort in an area of the body that is no longer there or no longer functions (for example, in paralysis) (Flor 2002). It may be perceived as a shooting/shocking type of pain, a burning sensation, a stabbing pain, a muscle cramp or even the feeling of a squeezing of a tight band around the affected area. This pain is unique in that it is perceived in the missing limb and not at the site of surgery nor proximal to the lesion. The main reasons for amputation include: vascular deficiency, infection, diabetes and trauma (Aternali and Katz 2019). Following an amputation, PLP appears during the first month and then again becomes more predominant 1 year later (Kuffler 2018). Afterwards, with time, the frequency and intensity of the pain is reduced. Approximately 50 to 80 percent of all amputees experience PLP. PLP appears to be neuropathic in origin, involving peripheral neurons (stump and neuroma hyperactivity), central neural mechanisms (spinal cord changes, cortical reorganization and cortical-motor sensory dissociation, changes in body schema),

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and psychogenic mechanisms (Flor 2002, Geneen et al. 2017, Subedi and Grossberg 2011). PLP used to be thought of as psychotropic in origin (Subedi and Grossberg 2011). Understanding the multifactorial component of PLP allows one to direct treatment procedures towards reducing phantom limb pain in amputees.

Participation in regular, moderate exercise by individuals has been demonstrated to decrease the chronic pain associated with a variety of conditions (e.g., fibromyalgia, arthritis, back and menstrual pain) (Geneen et al. 2017, Landmark et al. 2011, Law and Sluka 2017). Regular exercise may alter the centrally-mediated pain processing pathways by decreasing the excitability of central neurons and increasing the release of serotonin and endogenous opioids within the inhibitory pain pathways of the brainstem. However, very little research examining the effects of physical activity on phantom limb pain has been done. The purpose of this study is to investigate the role of exercise in the modulation of phantom limb pain by first examining the literature on physical activity and PLP and then conducting a survey on the effects of physical activity in amputees on their perceived PLP.

Literature Review

Within the clinical setting, pain management is commonly determined by the cause of pain (i.e., surgery cancer, bone fractures, neuropathic pain, osteoarthritis, rheumatoid arthritis, and herpes zoster etc.). For amputees, pain management is targeted towards the source of pain (peripheral, central and spinal), using analgesics, physical and psychological measures (Chapman 2011). A combination of analgesics and physical measures have been used to treat PLP (Batsford et al. 2017). These treatments focus mainly on reducing the intensity of pain. Medications to help alleviate the pain or discomfort with PLP include anesthetics, opioids, acetaminophen, nonsteroidal anti-inflammatory drugs (NSAIDs) and/or antidepressants (Subedi and Grossberg 2011). The type of pain medication prescribed will depend upon the time since the amputation occurred (McCormick et al. 2014). Commonly, intravenous ketamine and morphine are used for short-term (perioperative) treatment of PLP, gabapentin is used to treat for an intermediate duration (6 weeks) and oral morphine is prescribed 8 weeks to 1 year post-operatively.

Acetaminophen and NSAIDs are the most commonly used medications to treat PLP over the long-term (Kuffler 2018, Subedi and Grossberg 2011). Although, its exact mechanism of action is still not completely understood, acetaminophen works in the central nervous system involving serotonergic pathways to block pain perception. NSAIDs reduce nociception peripherally and centrally by inhibiting the enzymes that are required for prostaglandin synthesis. Opioids have been known to help diminish cortical reorganization, disrupting one of the proposed mechanisms of PLP. Gabapentin has analgesic properties which reduce the amount of pain felt (Abbass 2012). Tricyclic antidepressants have shown promise in helping to reduce symptoms of PLP by inhibiting neuropathic pains (Kuffler 2018). Other medications such as pre-emptive analgesia and

anesthesia, anticonvulsants, and NMDA receptor antagonists need further research to understand their effects on PLP.

Non-pharmacological treatments are used in tandem with medications or on their own. These approaches are used more frequently due to the lower risks associated with them, as some pharmacological treatments may increase PLP symptoms and can lead to potential addiction (Hyung and Wiseman-Hakes 2022). These treatments include mirror therapy (the use of a mirror to mimic the idea that one's limb is in intact and seeing painless movement), transcutaneous electrical nerve stimulation (TENS), acupuncture, massage, surgical intervention (removing scar tissue; muscle reinnervation), biofeedback (using a device to measure physiological changes in the body), hypnosis, graded motor imagery (limb recognition, imagined movement followed by mirrored movement), physiotherapy and phantom exercises (Aternali and Katz 2019, Batsford et al. 2017). Surgical intervention is highly invasive and problematic for postoperative complications, so it is often avoided (Hyung and Wiseman-Hakes 2022). Thus, it is vital to find a treatment option that works consistently for individuals to manage their symptoms of PLP.

Participation in regular physical activity may reduce the intensity, frequency, or duration of chronic pain (Geneen et al. 2017). Although there has been a substantial amount of research performed to examine the effects of physical activity or exercise on aerobic capacity in amputees, this research does not appear to include the effects it may have on PLP. The research that has been done to date focuses predominantly on phantom exercises whereby the participants of a study are asked to move their amputated limbs through their range of motion every time they begin to feel a sensation of pain (Ülger et al. 2009) instead of participating in regular physical activity as a treatment option (Brunelli et al. 2015). A summary of the studies investigating phantom exercise as a treatment for phantom limb pain is provided in Table 1.

Ülger et al. (2009) were one of the first to examine the effects of a generalized exercise program (involving dynamic exercise, isometric exercise, muscle stretching and muscle strengthening) combined with prosthetic training on PLP. Each of the general exercises were performed ten times in one session and repeated twice daily. They compared this exercise program with that of a program of phantom exercises that also included prosthetic training. The phantom exercises were repeated up to fifteen times whenever phantom limb pain was experienced. After four weeks of daily exercise, the intensity of PLP decreased in both groups. The results of the study indicated that exercise can be used to treat PLP.

Zaheer et al. (2021) recently used a similar idea with phantom exercises, however they chose to include other treatments such as physiotherapy and mirror therapy along with the exercises. They compared the effects of mirror therapy and conventional physical therapy (involving conventional therapeutic exercises) with a group of participants who also performed a combination of treatment approaches including phantom exercises, mirror therapy and physical therapy (i.e., the experimental group). Results of their study indicated a significant reduction in the intensity of pain in the experimental group, as well as the participants having an easier time managing their PLP.

Both studies mentioned above suggest the important role which phantom exercises can have in pain management for patients with PLP. However, it is important to note that when phantom limb exercises are compared to mirror therapy both through experimentation (Külünkoglu et al. 2019) and as well as through a review of the literature (Wang et al. 2023), mirror therapy appears to have greater efficacy. Thus, more research is needed to determine effective pain management techniques for amputees with PLP.

Table 1. *Studies Examining the Effects of Phantom Exercises on PLP*

Reference	Design	Participant	Pain Tool	Intervention	Duration	Results
Külünkoglu et al. (2019)	RCT	23M /17F 18 to 45 years	VAS BDI	Mirror therapy *vs* phantom exercise	4 weeks	Decrease in PLP and increase in QoL with both treatments, greater with mirror therapy
Ülger et al. (2009)	RCT	16M / 4F 30 to 45 years	VAS	Phantom exercise *vs* general exercise training	4 weeks	Decrease in PLP intensity
Zaheer et al. (2021)	RCT	17M / 4F 40 to 45 years	VAS	Mirror therapy and physiotherapy *vs* mirror therapy, physiotherapy and phantom exercise	4 weeks	Decrease in PLP intensity

Legend: BDI = Beck Depression Inventory; F = females; M = males; RCT = randomized control trial; VAS = visual analogue scale

This study is one of the first to look at physical activity, in general, as a potential treatment to reduce PLP. It is hypothesized that regular physical activity will decrease PLP.

Methodology

Participants eligible to volunteer for this study were between the ages of 18 to 80 years old, had a lower limb amputation and experienced phantom limb pain. Although our goal was to recruit at least 20 participants; a total of 9 amputees volunteered to participate in this study. The study was approved by Trent University's research ethics committee (protocol number 27917).

Due to COVID-19 restrictions, this study was conducted online during April 2022 (April 4th to17th, 2022), using a virtual survey link. The survey was comprised of 25 open-ended questions and took on average 10 to 15 minutes to complete.

The survey was shared on the social media platform "Facebook" and with permission from the administrator of four amputee support groups (Central East Ontario Amputee Support Group, Northwestern Ontario Amputee Support Group, Amputee Coalition of Canada, and Amputee Coalition of Toronto). A link to the survey was directly posted on these pages and the survey was completed anonymously. Each participant provided informed consent before beginning the survey after reading through the consent form. The survey was created using Qualtrics software.

The questions which were asked of the participants are outlined in Table 2. To be eligible for the study, participants had to experience PLP. The participants were first asked general questions regarding their amputation and use of a prosthesis. If participants used a prosthesis, they were asked about the type they used. They were also asked when they first began to feel pain after being amputated, how long each episode of PLP lasted and the extent of their pain. To gain a better understanding of how PLP was treated, questions regarding the types of treatments the amputees were prescribed were asked. This included use of medications, therapies to help visualize the missing limb (mirror therapy or virtual reality), physiotherapy, phantom exercise, and anything else they may have tried. If participants combined a variety of treatments, this was acknowledged, and they were asked if a combination of treatments was more helpful then a single treatment alone. The types of medications that were used to control pain was also assessed by the survey.

Table 2. *Phantom Limb Pain Questionnaire*

General Questions	Activity-Related Questions
1. Do you experience PLP?	13. Do you participate in PA?
2. When did your amputation occur?	14. Was PA selected by choice or prescribed?
3. Amputation type?	15. Does PA help the frequency of PLP?
4. Do you have a prothesis?	16. Does PA help the duration of PLP?
5. Prothesis type?	17. Does PA help the intensity of PLP?
6. How long post-amputation did feelings of PLP begin?	18. Describe your level of PA
	19. What types of PA do you participate in?
7. How long does your PLP pain last?	20. How often do you work-out?
8. How severe is the pain?	21. How long do you work-out for?
9. Treatments used for PLP?	22. Do some PA work better than others?
10. Do you take meds for PLP?	23. Do you combine PA with other treatments?
11. Medication type?	24. Does the treatment combination help PLP?
12. Did alternative treatments help treat PLP?	25. What treatment combinations help PLP?

The participants' physical activity patterns were also assessed with the survey. This included examining whether the amputees were physically active or not and if the decision to become physically active, post-surgery, was by choice or suggested by a healthcare professional (physician or nurse). We investigated whether participation in regular physical activity reduced the frequency, duration, or intensity of phantom limb pain. Questions were also asked about how often participants were physically active and the type of physical activity they participated in. Participants were asked if they combined physical activity treatments with other treatments or medications. The survey data was also used to examine any trends between participants' experiences, their past treatments, and

current experiences with physical activity. The collected data was analyzed using Microsoft Excel and descriptive statistics and confidence intervals were calculated.

Results

Most participants became amputees within the last 5 years. Seven participants had below the knee amputations (with two reporting a trans-tibial amputation) and two participants had an above the knee amputation. One participant was a bilateral amputee. Participants in this study all experienced PLP symptoms, with symptom severity ranging between moderate to severe. The amputees experienced the start of their PLP either immediately after surgery or a few days afterwards (Table 3). Participants reported that each episode of PLP lasted a few minutes to never subsiding (i.e., lasting 24 hours/7 days a week). All participants reported use of a prosthesis for daily activities. The types of prosthesis that the participants used ranged from suspension sleeves to pin locks. For some individuals, use of a prosthesis contributed to some of the pain that was experienced while performing physical activity.

A variety of treatment approaches were taken by the participants to control their PLP. Five of the nine participants (56 percent of participants) used massage to soothe their phantom limb pain; one individual relied on meditation and prayer; another participant used self-hypnosis to minimize their pain and two individuals relied on mirror therapy. Regarding the effects of massage, participants could feel parts of the body that were not there when they massaged their stump. One individual reported the following: “I can rub underside of the stump and feel my heel, same with sides of the foot, a certain spot and feel each toe…fascinating”. A slightly higher proportion of participants utilized pain medication for pain control. Sixty-six percent of the participants (6 out of nine participants) were currently using medications to treat their PLP symptoms. Tylenol and ibuprofen were most used to treat PLP, however, medications such as gabapentin, Lyrica and cannabinoids were also taken by the participants to control their pain. Two individuals took pain medications, and one individual massaged their limb prior to participation in physical activity to prophylactically reduce any pain they might experience during activity.

Table 3. *PLP Characteristics of the Participants*

Variable	Number (n)	Percentage (%)
Start of PLP following amputation		
• Immediately	3	33
• After a few days	3	33
• After 1 week	2	22
• After 1 month	1	11
Length of each PLP bout (duration)		
• Few min	4	44
• Few hours	3	33
• 24/7	2	22
Pain Severity of PLP (intensity)		
• Moderate	4	44
• Severe	4	44
• Very severe	1	22
Take medications to relieve PLP?		
• Yes	6	66
• No	3	33
Participate in physical activity to relieve PLP?		
• Yes	7	78
• No	2	22

Of the nine participants, seventy-eight percent participated in mild to moderate physical activity regularly to relieve their PLP. Most of these individuals did so by their own volition, whereas two of the participants were also encouraged to do so by their health care practitioner. Table 4 summarizes the activity patterns of the participants. Each exercise session lasted in duration between 10 to 60 minutes. Of those that were active, the most common activity was walking. Swimming was the second most common activity for those individuals that did not have an open wound. The participants noted that no specific exercise worked better at reducing PLP than the others. The other eighteen percent of participants did not partake in physical activity and were likely sedentary despite answering "not applicable" and "mild" as the level of physical activity intensity question on the survey. We also determined whether participation in physical activity helped with PLP.

Table 4. *Activity Patterns of Participants with PLP*

ID	Type of Preferred Activity	Intensity	Frequency	Duration
1	Walking, line dancing	Moderate	>3 times/week	30 – 60 min
2	Walking	NA	Never	NA
3	Wheel-chairing	moderate	>3 times/week	20 – 60 min
4	Stretching, walking, yoga, swimming.	moderate	"not enough"	NA
5	Walking	Mild	< 30 min/week	Up to 30 min
6	Yoga, swimming	moderate	< 30 min/week	45 min
7	Walking	Mild	NA	NA
8	Swimming, walking, hiking	Moderate	>3 times/week	2 – 6 hours
9	Walking	Mild	>3 times/week	10 min per day

Table 5 represents the responses of the participants on the extent that participation in physical activity helped with either the intensity, frequency and/or duration of PLP.

Table 5. *Effects of Physical Activity on Reducing PLP of the 7 Active Participants*

	Yes		No		Not sure		95% CI
Phantom Limb Pain	**N**	**%**	**N**	**%**	**N**	**%**	**For "yes"**
Intensity	4	57	2	29	1	14	[29 to 100]
Frequency	3	43	3	43	1	14	[10 to 90]
Duration	1	14	4	57	2	29	NA

Legend: CI = Confidence interval; NA = not applicable

Participation in regular physical activity had the greatest effect on the intensity of PLP, with fifty-seven percent of the participants reporting a reduction in the intensity of pain they experienced during a PLP episode, this was in the ninety-fifth percent confidence interval [29-100 percent] for this response. Similarly, the frequency of PLP episodes was altered by participation in regular physical activity as the proportion of "yes" responses also lay within the 95 percent CI [10 to 90 percent]. In contrast, fifty-seven percent of participants indicated that the duration of PLP symptoms was not altered by participating in physical activity.

Discussion

The results of this study demonstrated that pain management (specifically for PLP) by amputees was directed towards physical measures such as physical activity, massage as well as medication use. There were a few participants who also used psychological measures to help with their pain which included mirror therapy, prayer, and self-hypnosis. More participants selected physical activity over medication use for PLP relief. The most prominent finding of this study was

that participation in regular physical activity reduced the severity (intensity) and frequency of PLP and as such these results support our hypothesis.

Seventy-eight percent of participants regularly performed physical activity and sixty-six percent of participants relied on use of medication to relieve PLP. Lansbury (2000) examined pain management in 72 elderly individuals who were over 65 years of age and were experiencing chronic pain. Preferred pain-treatment methods were those methods that could be self-administered. Conventional treatment methods such as medication, exercise (which is more standardized than physical activity) and physiotherapy were least preferred. This may explain why medication used in this study was less preferred over participation in physical activity for pain management.

Several mechanisms have been proposed to explain why participation in physical activity might reduce pain severity and frequency in individuals experiencing pain. This includes modulation of physiological responses within the central nervous system (i.e., decreasing the excitability of central neurons and changing neuroimmune signaling) as well as stimulation of the release of endogenous opioids and serotonin within the brain pain inhibitory pathways (Law and Sluka 2017). Studies which have been designed to specifically examine the effects of phantom exercises on PLP have suggested that pain, muscle cramps and fatigue occur when a limb is held in one position for a long time. Phantom exercises are designed to move the patient's limb through their range of motion. The intensity of PLP is reduced when the limb is moved through phantom exercises (Külünkoglu et al. 2019, Ülger et al. 2009, Zaheer et al. 2021). This movement reduces tension and induces relaxation of the muscles above the amputated limb which in-turn reduces PLP. Although, our study participants did not report participating in phantom exercises, perhaps due to a limited awareness of this method, participation in regular moderate exercise might have the same effect.

Alternative physical methods used by the participants to control PLP, such as massage and mirror therapy, may work through different mechanisms. Massage therapy of a 30 minute duration has been shown to reduce pain in a variety of patient populations (medical, surgical and obstetric patients) (Adams et al. 2010). Massage therapy may be effective in relieving the burning sensation associated with PLP, since it is thought to stimulate large nerve fibers and reduce the transmission of noxious stimuli. Mirror therapy may have a role in cortical re-organization as pain relief with this method may be due to activation of contra-lateral neurons in the alternate brain hemisphere (Ülger et al. 2009).

For individuals that reported that they participated in physical activity, on average they participate in at least 30 minutes of exercise at least 3 times per week. The most common types of exercises were walking or stretching but other types of physical activity were swimming, yoga, resistance training and dance. The participants noted that no specific exercise works better at reducing physical activity than the others. Fifty percent of the participants combined various treatments with physical activity.

Of the individuals who combined treatments, they reported combining pain medication (acetaminophen) with their participation in physical activity and yet

they experienced no additional difference in frequency, intensity or duration of PLP when this was done. Further research could be done to determine when pain medication should be taken (prior to, during or following physical activity) or what type of pain medication might be most effective to attenuate PLP that occurs during activity. In Canada (where this study takes place), cannabis use is legalized and some individuals in this study responded to the survey that they used cannabis for the treatment of their PLP and, as a result, have seen reductions in their symptoms. If possible, researchers might examine how cannabis affects an individual with PLP and if using this substance in combination with physical activity may further reduce or even eliminate episodes of PLP.

Furthermore, a few of the participants noted that they found that their PLP symptoms were increased when exercising with a prosthesis on. There is minimal research on how individuals who have a prosthesis are impacted in their ability to be physically active, whether it be due to the type of prosthesis, or the forces being applied to the amputated limb through the prosthesis or another reason. There does not appear to be any peer reviewed articles that address this issue. To further understand whether participation in physical activity is modulated by a prosthesis, an in-depth study is needed, and this may also help address the issue of why some individuals with amputations struggle to be active or choose to remain more sedentary. The data collected through this study demonstrates that there is a significant amount of variability between the amount of physical activity performed by the participants.

Although regular, moderate-intensity aerobic physical activity of at least a 30 minutes duration, has been recommended for over 2 decades (Esposito and Fitzpatrick 2011) for health promotion, health care professions are still remiss on prescribing it. Only two participants (22 percent) of our study had physical activity prescribed by their health care practitioners as treatment for improved health and possible pain reduction. This value is lower than what is normally reported in the literature. In previous research it has been shown that between 34 to 48 percent of physicians (Damush et al. 1999, Wee et al. 1999) and 48 percent of nurse practitioners (Tompkins et al. 2009) prescribe physical activity as treatment. The lack of exercise prescription for the population of our study is most likely because they were amputees and there is limited information available on role of exercise for these individuals. Possible ways to adapt the idea that physical activity benefits those with PLP may include looking in depth at the effects of specific types of exercise, such as resistance training, anaerobic exercise, high intensity interval training and/or aerobic exercise on PLP. To the best of our knowledge, there are no studies specifically looking at individual exercise plans for amputees with PLP. Moreover, most health care practitioners tend to target sub-groups of patients that are known to benefit from regular physical activity (i.e., younger patients, sedentary individuals, and obese patients). Another factor to consider are that physicians and nurses who prescribe exercise for their patients are more likely to do so if they are active themselves (Abramson et al. 2000, Esposito and Fitzpatrick 2011).

Limitations

The small sample size of this study was a significant limitation to our outcome. Only nine individuals volunteered to participate when the intended goal was twenty participants. Should the study have been conducted over a longer time frame, and possibly including more amputee support groups from across Canada or around the world, there would have likely been a higher number of participants and the results would have been a more accurate representation of the population studied. There are also many limitations with a survey-based research study. This type of research may yield inaccurate results due to the individuals not answering the questions honestly or not understanding the questions and there was no way for the participants to be monitored. We could not ensure that someone else was answering the questions on the survey while the surveys were being completed. Finally, to avoid personal identification in such a small group, we did not include the sex or specific age of the participants. This additional information may have provided insight into which individuals are more likely to participate in physical activity as a treatment for their PLP.

Conclusions

This study was intended to be a pilot study, suggesting that physical activity in general and not just exercises of the phantom limb (phantom exercise) has the potential to improve the effects of PLP in individuals, specifically people with amputated limbs. This is one of the first studies to examine the effects of amputees' participation in regular physical activity on PLP. The results of our study demonstrate that regular moderate-intensity physical activity can be used safely to decrease the intensity and frequency of lower-leg PLP in amputees. This is encouraging for amputees as it has been demonstrated that the presence of PLP leads to a reduction in the quality of life (QoL). A reduction in QoL is a major factor limiting amputees from participating in rehabilitation programs and their future prognosis (Padovani et al. 2015). Thus, it may be assumed that a reduction in the intensity and frequency of PLP episodes could lead to an improvement in the quality of life of these individuals and subsequently enhance their prognosis.

Nurses are in a unique position to recommend physical activity to their patients (Speck 2002) since they are the one health care professional that spends the most time with their clients. Health care professionals should encourage their patients with amputations to exercise, recommending daily walks and stretching. Future research should be done to examine the effects of regular exercise programming "in person" on PLP in amputees.

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