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SHORT COMMUNICATION

EFFECTIVENESS OF PHANTOM EXERCISES FOR PHANTOM LIMB PAIN: A PILOT STUDY

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Objective: **To investigate the effects of phantom limb exercises on phantom limb pain.**
Methods: **A total of 20 traumatic amputees participated in the study. Ten received phantom exercises and prosthetic training, and 10 were treated with routine prosthetic training and a general exercise programme. Intensity of pain was evaluated using a 10-cm visual analogue scale before therapy and after 4 weeks of therapy.**
Results: **Baseline scores on the visual analogue scale were similar between the groups. Pain intensity decreased in all subjects after 4 weeks of treatment in both groups. According to the visual analogue scale scores at the end of 4 weeks, the phantom exercises group differed significantly from the general exercise group ($p < 0.05$).**
Conclusion: **Phantom exercises appear to be effective in reducing phantom pain, but further research is required to confirm this.The results of this study indicate that phantom exercises can be used safely to alleviate phantom limb pain in lower and upper limb amputees.**

Key words: phantom limb, exercise, amputees.

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INTRODUCTION

Phantom limb pain (PLP) is pain felt in an extremity that has been amputated (1). PLP is considered as a type of neuropathic pain caused by pathology in the central or peripheral neurones (2).The so-called neuromatrix mechanism causing pain is defined as a "neural organization" that is carried by genes and modified by sensory experiences. (3). The neuromatrix is a network of neurones all of which discharge separately. According to this mechanism the abnormal stimuli reaching the neuromatrix following amputation change its structure, causing the input to be interpreted as pain. Both the absence of normal stimuli and the over-discharges from the damaged neurones are thought to be responsible for the occurrence of PLP. Similarly, somatosensorial pain memory may revive after amputation and cause PLP (4).

Treatment of PLP is very difficult. There are different treatment methods for amputees with PLP, for example, surgical techniques, medical and psychological therapies, mirror therapy or mirror box usage, and immersive virtual reality (5–13). Mirror therapy, in particular, exploits the brain's predilection for prioritizing visual feedback over somatosensory/proprioceptive feedback concerning limb position. Moseley et al. (6) reviewed current evidence that mirror therapy reduces pain, summarized relevant findings concerning the other effects on the human brain of using mirrors, and suggested implications for clinical practice and research. In addition, MacIver et al. (5) showed that significant associations exist between different types of PLP and cortical reorganization, and that regularly practised mental imagery exercises result in pain relief, which is associated with a reduction in cortical reorganization.

The aim of the current study was to investigate the effectiveness of phantom exercises, such as mental imagery exercises, the mechanism of which has been explained by MacIver et al. (5).

METHODS

A total of 20 amputees participated in the study. Patients with upper and lower limb amputation between the ages of 30 and 45 years with traumatic (traffic accident) amputations and with PLP (at least 7 points on a visual analogue scale (VAS)) were included. The presence of PLP and/or phantom sensation was based on the answers to the following questions: (*i*) Do you feel the amputated part of your limb? (*ii*) Do you feel pain in the amputated part of your limb? If the answer to the second question was "yes" the severity of the pain was investigated using the VAS (0–10 cm). All the assessments were conducted by the same physiotherapist.

Subjects were asked to stop taking drugs during the treatment. Subjects with phantom sensation but without phantom pain, and bilateral amputees, were excluded from the study; because the existence of an intact limb is important to achieve a facilitating effect.

Participants were assigned randomly into 2 groups, based on their arrival time in our clinic. The first patient was put into group I, and the second in group II and so on. Group I comprised 10 patients receiving phantom exercises and prosthetic training, and group II comprised 10 patients receiving routine prosthetic training and a general exercise programme. The general exercise programme consisted of strengthening, stretching, dynamic, and isometric exercises based on the level of amputation and their assessment results. Group II performed general exercises 10 times twice daily, for 4 weeks.

The phantom exercises were administered as follows: (*i*) subjects were asked in which position they felt the phantom limb; (*ii*) they were asked to place the intact limb in the same position as they felt

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Table I. *Demographic characteristics of the patients in the phantom exercises and prosthetic training group (group I) and in the general exercise programme group (group II)*

	Group I (n=10) Mean (SD)	Group II (n=10) Mean (SD)	*p*
Age, years	41.60 (4.17)	42.10 (4.48)	0.76
Height, cm	169.20 (6.17)	168.10 (4.88)	0.90
Weight, kg	72.80 (5.67)	72.10 (4.35)	0.64
Time since amputation, months	2.7 (0.82)	3.30 (1.15)	0.23

SD: standard deviation.

their phantom limb; (*iii*) they were asked to move both limbs in the opposite direction; (*iv*) they were then asked to return to the starting position again.

Exercises were repeated 15 times or until the phantom pain disappeared. Subjects were asked to perform the exercises if they felt the pain again.

Under the supervision of a physiotherapist, the patients performed these exercises until they no longer experienced any phantom sensation. They were told to repeat the exercises in the same way if they experienced any phantom pain or sensation. The patients continued to perform the exercises for 4 weeks. A physiotherapist also recorded the intensity of pain with the use of a 10-cm VAS before the therapy and after 4 weeks of therapy.

The study was approved by the medical ethics committee of Hacettepe University. Patients were told that each therapy was being examined for efficacy, and each patient provided written informed consent.

Patients were discharged after 4 weeks of therapy and were given a home exercise programme. Two months after discharge the patients were telephoned and invited to our clinic in order to evaluate their PLP 6 months later.

Statistical analysis

The results were analysed using SPSS software. The Wilcoxon signed-rank test was used to determine the differences between pre- and post-treatment values. The Mann-Whitney *U* test was used to examine the different results of each group. A p-value of <0.05 was considered to be statistically significant.

RESULTS

Of the 20 traumatic amputees who participated in the study, 4 were female and 16 were male. All the patients applied to our clinic for their first prosthesis. The demographic characteristics of the subjects are shown in Table I.

While 5 lower limb amputees and 5 upper limb amputees were included in group I, 6 lower limb amputees and 4 upper limb amputees were included in group II. Baseline scores on the VAS were similar between the groups (Table II). PLP intensity showed an important reduction in all subjects after 4 weeks of treatment in both groups ($p<0.05$) (Table II). According to the VAS scores after 4 weeks, the phantom exercise group had less pain than the control group ($p<0.05$) (Table II). When the patients were telephoned 2 months after discharge, they reported that they performed phantom exercises during PLP and experienced a decrease in the frequency of PLP.

DISCUSSION

In this study investigating PLP in upper and lower limb amputees, both phantom exercises and general exercises resulted in significant pain relief at the end of the 4 weeks' treatment. In addition, patients who performed the phantom exercises had less pain at 4 weeks than those who performed general exercises. It was thus determined that phantom exercises had useful effects on PLP.

A search of the literature for studies related to treatment of PLP revealed that different treatment methods used have had beneficial effects on the relief of PLP. Two such studies were those by MacLachan et al. (8) and Chan et al. (10), in which mirror therapy was used. Their findings showed that PLP was diminished after the treatment, as found in our study. They concluded that the pain relief associated with mirror therapy may be due to the activation of mirror neurones in the hemisphere of the brain contralateral to the amputated limb (8, 11).

Several theories have been proposed to explain PLP, e.g. peripheral, central, and supraspinal theories. There is now good evidence indicating that cortical reorganization occurs following amputation, and it has been suggested that this may be an important cause of PLP (12). In studying this theory, Flor et al. (13) found a strong direct correlation between the amount of cortical reorganization and PLP, but not phantom limb sensation. Like Flor et al. (12), Grüsser et al. (14) found no correlation between cortical reorganization and non-painful phantom sensations.

Flor et al. (12) stated that surveys of amputees indicate the ineffectiveness of treatments for PLP that fail to address its underlying mechanisms. Mechanism-based treatments were found to be relatively effective in a few small studies. Pharmacological and behavioural treatments resulting in vasodilatation of the residual limb help to relieve the burning component of PLP, but not other features. Treatments to decrease muscle tension in the residual limb reduce cramping, but not other features (12).

Some researchers have reported that cramping and squeezing phantom sensations reflect muscle tension in the residual limb. Treatments that reduce muscle tension in the residual limb diminish cramping phantom pain. According to previous

Table II. *Comparison of values between pre- and post-treatment in the groups*

	Group I		Group II	
	Pre-treatment Mean (SD)	Post-treatment Mean (SD)	Pre-treatment Mean (SD)	Post-treatment Mean (SD)
Phantom sensation, VAS	8.40 (1.08)	6.30 (0.95)*	8.50 (1.08)	7.90 (0.88)
Phantom pain, VAS	9.20 (0.79	6.10 (0.74)*,**	9.30 (0.82)	7.60 (0.52)*,**

*$p<0.05$ between the pre-treatment and post-treatment groups.
**$p<0.05$ within the post-treatment groups.
SD: standard deviation; VAS: visual analogue scale.

research, cramping phantom pain decreases during activities that increase overall levels of contraction (9).

The outcome of our study showed that the phantom exercises that we used for PLP reduced phantom pain intensity. PLP intensity was also diminished in the other group, in which routine prosthetic training was given. Although there was a decrease in pain in both groups, the phantom exercises group differed significantly from the other group.

Our subjects stated that they felt pain in their phantom extremities, especially when they were held in the same position for a long time causing tiredness. For this reason, they said that their pain intensity had increased. After the phantom exercises, the subjects felt less PLP due to the relaxation of the phantom limb. This indicates that phantom exercises that alter muscle tension and position in the residual limb can influence the intensity of phantom pain, as in studies conducted by Flor et al. (12).

On the other hand, when performing bilateral exercises, muscle tension can be diminished and cause the residual part of the amputated limbs to relax. Another important reason for this relaxation might originate from the visual input (8–11).

A diminishing activation of input from the residual limb might reduce cortical reorganization and so the phantom pain intensity decreases, as stated in some previous studies (11, 12, 15).

There are many alternative approaches in the literature for patients who experience PLP. One of these is prosthetic usage. It has been shown in many studies that intensive use of myoelectric prostheses reduced both PLP and cortical reorganization (1, 15).

We also found that the intensity of PLP of the subjects who participated in the prosthetic training was reduced after treatment. We can conclude that the ongoing stimulation, muscular training of the stump, and visual feedback from the prosthesis might have a beneficial effect on both cortical reorganization and PLP, as reported by Lotze et al. (15).

To our knowledge, this is the first study to investigate the effect of phantom exercises on PLP in amputees. It is thought to be important for the rehabilitation team that the phantom exercises yield effective outcomes in amputees with acute PLP during the 4-week period of prosthetic training and rehabilitation. Phantom exercises are very practical, comprehensible and do not require any clinical equipment. Further research is planned into the effect of phantom exercises in different causes and levels of amputation, and the long-term effects of phantom exercises in amputees, using a greater number of participants.

In conclusion, phantom exercises appear to be effective in reducing PLP, although there is insufficient evidence about them. The results of this study show that phantom exercises can be used safely to alleviate PLP in lower and upper limb amputees.

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