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Effects of routine physical therapy with and without mirror therapy on phantom limb pain and psychosocial adjustment to amputation among prosthesis users

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Abstract

Introduction. The study objective was to determine the effect of conventional physiotherapy treatment with and without mirror therapy on phantom limb pain and psychosocial adjustment to amputation among prosthesis wearers.
Methods. It was a randomized controlled trial. Data were collected in the Physiotherapy Department of the Pakistan Society for the Rehabilitation of the Disabled, Lahore, and University of Lahore teaching hospital, Lahore. Overall, 36 participants with unilateral lower extremity traumatic amputation and phantom limb pain were recruited.
Results. At baseline, the experimental and control groups were comparable for both Numeric Pain Rating Scale (6.17 ± 1.80 and 6.33 ± 1.74) and psychosocial adjustment of the Trinity Amputation and Prosthesis Experience Scales, i.e. general adjustment (19.22 ± 2.39 and 19.67 ± 2.76), adjustment to limitation (12.78 ± 4.36 and 11.72 ± 3.69), and social adjustment (20.22 ± 1.83 and 20.05 ± 2.87). At the end of the 4th week, a significant reduction in pain was observed (2.27 ± 1.17 and 4 ± 1.37). Changes were recorded in general adjustment (22.27 ± 2.63 and 21.89 ± 2.21) and adjustment to limitation (19.67 ± 2.54 and 16.00 ± 3.97) but no significant difference was seen in social adjustment (22.67 ± 1.90 and 21.89 ± 1.99).
Conclusions. Mirror therapy combined with routine physical therapy is a beneficial approach and shows better results in mitigating phantom limb pain and in psychosocial adjustment to the prosthesis than routine physical therapy alone.
Key words: amputation, mirror therapy, phantom limb pain, psychosocial adjustment

Introduction

Amputation is a devastating incident that can result in psychological, physical, and social manifestations [1]. It is also considered a rehabilitative procedure that can bring about beneficial outcomes for the individual [2]. The dormant adverse impact of amputation as a partial or total loss of daily functions and quality of life is severe [3]. Traumatic limb amputation will result in a related pain that is further categorized as pain of a residual limb or a phantom limb [4]. Phantom limb pain (PLP) is perceived as a sensation of pain by an individual in the amputated portion of extremity that was removed surgically [5, 6]. Intense episodes of PLP among amputees are further characterized as tingling, throbbing, electric shock sensation, stabbing, and cramped painful immobile sensation [7]. Pain in the residual extremity is sensed in the remaining stump [6].

PLP and phantom limb sensation incidence is reported to be 72% and 84%, respectively, among amputees immediately after the operation and 67% and 90% after 6 months of amputation. There are differences in the incidence of PLP among upper and lower limb amputees. Estimations of long-term prevalence of PLP and phantom limb sensation vary considerably [8].

The chronological order of PLP can directly affect the patient's quality of life and compromise activities of daily living [9]. PLP and residual limb pain are correlated with depression and anxiety, influencing the quality of life. Among the consequences of PLP, there are functional limitations and activity restrictions [10]. Among prosthesis users, PLP potentially compromises the psychosocial and professional re-establishment [11].

Despite extensive evidence available, PLP treatment is still challenging for clinicians. They still need innovative and effective therapeutic strategies to manage the condition. The various therapeutic options [12] comprise pharmacological and non-pharmacological treatment. Pharmacology is most commonly used as a first line treatment of chronic pain as it is cost-effective. Non-pharmacological treatment includes transcutaneous electrical nerve stimulation [10], spinal stimulation [13], prosthesis [14], transcranial magnetic stimulation [15], acupuncture [16], etc. A major category of treatment is mirror therapy (MT), observation of movement, and motor imagery [17]. Many therapeutic options are available to treat PLP but still no strategy is widely accepted [18].

The MT procedure is based on the concept of using a voluntary reflection of movement in front of a mirror performed by an amputee's sound limb that will ultimately create a visual illusion of pain-free movement in the phantom limb. The goal of demonstrating the amputated limb by the imaginary limb movement is to obtain reintegration of its extension in the respective motor cortex, as well as in the respective sensory area, and therefore to alleviate the pain sensation interlinked with the cut-off of sensory information [19]. Effects of MT on motor functioning in the population affected by stroke have been investigated but there is limited evidence available that supports the impact of MT alone upon PLP. Actually, MT constitutes a comprehensive, cost-effective, easily administered home-based treatment with no significant side effects for amputees.

A systematic review conducted by Herrador Colmenero et al. [17] to investigate the effectiveness of MT, virtual visual feedback, and motor imagery on PLP summarized the currently published trials and evaluated the research quality.

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The authors reported that these conservative treatment interventions had a positive influence on PLP management. Still, however, there is a lack of literature and evidence supporting their effectiveness [17, 20].

A recent narrative review focused on an advancement in the management of PLP and on the evidence of treatment mechanisms described in randomized controlled trials performed and published over the previous 5 years. The results did not support the efficacy of any PLP therapy, although the authors concluded that still there was an evidence-based method to classify amputees. Most of the randomized controlled trials are underpowered. This compels researchers to explore new methods to manage, prevent, and reverse this chronic pain condition as PLP is highly prevalent [21].

The current randomized controlled trial, in which the assessor (a physiotherapist with more than 5 years of clinical experience) was unaware of the treatment given to the subjects (single-blind study), was conducted to determine the effects of MT combined with conventional physical therapy on PLP along with prosthesis satisfaction and psychosocial adjustment to amputation among prosthesis wearers.

Subjects and methods

Participants

Patients diagnosed with unilateral lower limb amputation and using prostheses were recruited in the study and screened for eligibility criteria. The inclusion criteria were as follows: (1) diagnosed PLP after unilateral lower extremity traumatic amputation [22]; (2) age of 18–45 years [22–24]; (3) any gender [25]; (4) baseline Numeric Pain Rating Scale (NPRS) score of 3 or more on the scale of 0–10 [25]; (5) at least 1 episode of PLP reported [25]; (6) sufficient cognitive and communication skills [25]; (7) using a prosthesis. The exclusion criteria involved: (1) restricted movement owing to any disease or condition or pain in the sound limb [23, 25]; (2) any diagnosed psychological disorder that could restrain the ability to concentrate during the therapy [23]; (3) residual limb pain [26]; (4) infectious or systematic diseases [27, 28]; (5) neuropathic pain except PLP [29]; (6) severe mental disorder, neglect syndrome, visual spatial hemineglect, confusion, or dizziness [29].

Randomization

The participants were allocated numbers in advance and then a table of random numbers was generated in Excel on the basis of these numbers. Simple randomization was performed with the help of the random number table. The first number was allocated to group A (experimental group, routine physical therapy + MT) and the second number was allocated to group B (control group, routine physical therapy). The same pattern was followed for the rest of the study participants for treatment allocation. The process was conducted by a health practitioner who was not directly involved in the allocated treatment.

Sample size estimation

A total of 30 participants were randomly divided into 2 equal groups. One patient in each group was not suitable for valid statistical significance. So, the sample size was considered as 30 (15 in each group). A 20% dropout was added and therefore 18 cases were included in each group. The sample size estimation formula was as follows:

$$n = \frac{(Z_{1-\beta} + Z_{1-\alpha/2})^2 + (\delta_1^2 + \delta_2^2)}{(\mu_1 - \mu_2)^2}$$

where: $\alpha = 5\%$; $1 - \alpha = 95\%$; $1 - \beta = 80\%$; $Z_{1-\beta} = 1.28$; $Z_{1-\alpha/2} = 1.96$; μ_1 (expected mean of PLP score in group A) = 6.10 [26]; μ_2 (expected mean of PLP score in group B) = 1.46 [23]; δ_1 (expected standard deviation in group A) = 0.74; δ_2 (expected standard deviation in group B) = 1.18; *n* (expected sample size in each group) = 18.

Interventions

In order to determine the efficacy of MT in alleviating PLP, routine physical therapy was considered as the conventional treatment. The 2 groups were as follows:

– Group A: In this group, patients received a routine physiotherapy program combined with MT (10 movements, 10 repetitions), a 15-minute session once a day, 5 days per week for 4 weeks.

– Group B: In this group, patients were treated with routine physiotherapy. The exercise program consisted of stretching, strengthening, and isometric exercises and prosthetic training (range of movement, mobility, balance training, sit-to-stand) depending on the amputation level and evaluation output. Routine physiotherapy involved a 35-minute session once a day, 5 days per week for 4 weeks [29]. The subjects were instructed to note their performance, specifying the type, period, and rate of recurrence [26].

For group A, a central flat mirror with a stand (640 × 900 mm) [30] was placed in a parasagittal position, forward-facing the participant, with the illuminating surface or mirror surface in the direction of the intact limb; as a result, the patient could observe the image of the intact extremity. The subjects were instructed to carry out movements of the intact limb while viewing their image and performing movements in the same pattern with the amputated limb. The image mimicked the surgically removed limb along with the sound extremity kinesis: a visual misapprehension was created that the amputated limb was moving concurrently. The study group patients were asked to try the following 10 movements, each repeated 10 times, with both the amputated and sound extremity: (1) bend (flex, curl) and unbend (extend or uncurl) unhurriedly your extremities at the knee joint concurrently; (2) calmly extend and flex your limb at the knee joint one after the other as when walking; (3) in a parallel, point your feet skyward and then down; (4) move your soles inside to each other and then outside away from each other; (5) move your feet while making a circle to the left and right; (6) raise your feet from the ground as when walking; (7) raise your toes up and down while attempting to keep the ankle and foot immobile; (8) clamp and unclamp your toes; (9) expand your toes and then relax them; (10) raise your big toe while pointing the other toes down, and then reverse it so that the big toe points downward and rest of toes upward.

There was a short gap between the movements and if at any instance the subject faced incapability to perform a desired movement to the break, the technique was stopped. The participants were instructed to start with gradual movements of the sound limb so that the amputated limb could maintain the pace with the mirrored image; the range of movement in the sound limb was increased in case there was a discrepancy of the range of movement present in the amputated limb [31].

The participants were assessed at baseline and at the end of the 2nd and 4th week.

Outcome assessment tools

Numeric Pain Rating Scale

The primary outcome measure includes NPRS. It was designed to assess the perceived pain. It has been used clinically in research to find pain intensity, and plan and assess treatment. NPRS measures pain intensity, with the scores of 0–10 (0 is considered as no pain, 10 stands for worst pain) [25]. Internal reliability for NPRS was calculated as 0.76 [32].

Trinity Amputation and Prosthesis Experience Scales

The secondary outcomes were psychosocial adjustment and prosthesis satisfaction as evaluated with the Trinity Amputation and Prosthesis Experience Scales (TAPES). Psychosocial adjustment is divided into 3 subscales: general adjustment, adjustment to limitation, and social adjustment, while prosthesis satisfaction is determined on the functional, aesthetics, and weight subscales. TAPES measures adjustment to physical limitation, which can affect social functioning. A physiotherapist assessed the subjects at baseline, and at the end of the 2nd and 4th weeks of treatment [33]. Internal reliability of TAPES was high, and previous evidence demonstrated different types of validity. The reliability of TAPES subscales, i.e. psychosocial adjustment, prosthesis satisfaction, and activity restriction, was calculated as 0.886, 0.862, and 0.833 (Cronbach) [34], while TAPES validity equals 0.75. The reliability of the TAPES prosthesis satisfaction subscales for function and aesthetics turned out to be 0.854 and 0.77 [35].

Statistical analysis

Frequency, mean, and standard deviation were used for descriptive statistics. The intervention period for each patient lasted for 4 weeks and data were collected at baseline and at the end of the 2nd week and 4th week for between-group cross-sectional comparison. Repeated measures analysis of variance (ANOVA) was applied to compare outcome measures between and within the experimental and control groups at baseline and after the end of the 2nd and 4th week. Statistical significance was assumed at the level of $p < 0.05$.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the review board of Faculty of Allied Health Sciences, University of Lahore (approval No.: IRB-UOL-FAHS/718-VIII/2020). The clinical trial has been registered in the Iranian Registry of Clinical Trials (https://www.irct.ir/) (identification No.: IRCT20200728048239N1).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

The CONSORT flow diagram of the study can be seen in Figure 1. A total of 2 subjects, 1 from each group (experimental and control), were lost to follow-up.

Table 1 shows the initial demographic and clinical characteristics of both groups. Before treatment initiation, the groups were comparable, i.e. no significant difference was observed between them for the variables of number of subjects who completed the follow-up, age, gender, time since amputation, level of amputation, daily time of wearing the prosthesis.

Table 2 displays descriptive statistics for the primary and secondary outcomes: within- and between-group results,

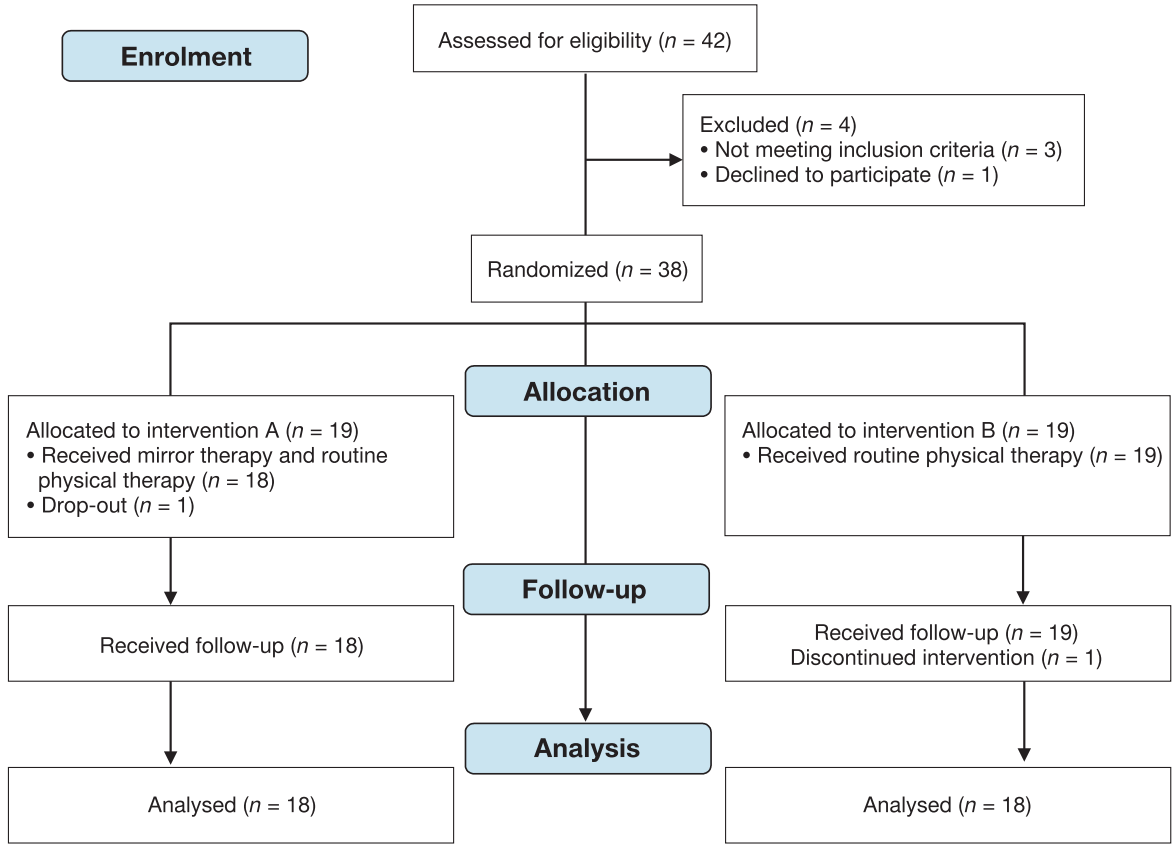

Figure 1. CONSORT flow diagram of the study

Table 1. Characteristics of subjects in the investigated groups

Characteristics	Study group (n = 18)	Control group (n = 18)
Age (years)	35.22	36.33
Gender (female/male) (n)	2/16	1/17
Level of amputation (below knee / above knee) (n)	14/4	12/6
Time since amputation (years)	2.83	2.67
Prosthesis wearing duration (hours per day)	8.16	9

Table 2. Comparison of changes in NPRS and TAPES scores within and between groups

Outcomes			Study group (Mean ± *SD*)	Control group (Mean ± *SD*)	$p^{(a)}$
Primary outcome	NPRS	Baseline	6.17 ± 1.80	6.33 ± 1.74	0.042*
		2nd week	4.05 ± 1.39	5.11 ± 1.56	
		4th week	2.27 ± 1.17	4.00 ± 1.37	
		$p^{(b)}$	0.001*		
Secondary outcome: TAPES (psychosocial adjustment)	General adjustment	Baseline	19.22 ± 2.39	19.67 ± 2.76	0.712
		2nd week	20.06 ± 2.41	20.89 ± 2.51	
		4th week	22.27 ± 2.63	21.89 ± 2.21	
		$p^{(b)}$	0.029*		
	Adjustment to limitation	Baseline	19.22 ± 2.39	19.67 ± 2.76	0.043*
		2nd week	20.06 ± 2.41	20.89 ± 2.51	
		4th week	22.27 ± 2.63	21.89 ± 2.21	
		$p^{(b)}$	0.05*		
	Social adjustment	Baseline	20.22 ± 1.83	20.05 ± 2.87	0.537
		2nd week	21.50 ± 1.94	21.17 ± 2.25	
		4th week	22.67 ± 1.90	21.89 ± 1.99	
		$p^{(b)}$	0.307		
Secondary outcome: TAPES (prosthesis satisfaction)	Functional	Baseline	16.05 ± 3.84	17.05 ± 3.47	0.391
		2nd week	19.22 ± 3.60	18.50 ± 2.73	
		4th week	22.44 ± 2.85	19.83 ± 2.35	
		$p^{(b)}$	0.00*		
	Aesthetic	Baseline	13.00 ± 3.10	13.33 ± 2.14	0.331
		2nd week	15.44 ± 3.14	14.55 ± 1.85	
		4th week	18.11 ± 2.74	16.33 ± 1.87	
		$p^{(b)}$	0.002*		
	Weight	Baseline	3.44 ± 0.51	3.2 ± 0.55	0.11
		2nd week	4.0 ± 0.48	3.5 ± 0.70	
		4th week	4.55 ± 0.51	4.05 ± 0.51	
		$p^{(b)}$	0.184		

NPRS – Numeric Pain Rating Scale, TAPES – Trinity Amputation and Prosthesis Experience Scales
[a] between-group comparison, [b] within-group comparison, * significant values ($p \leqslant 0.05$)

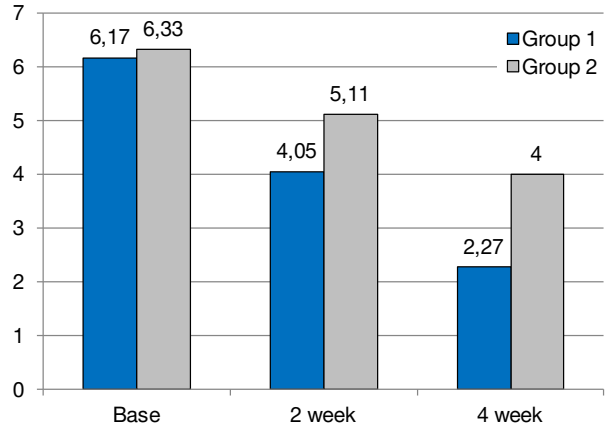

Figure 2. Descriptive statistics for Numeric Pain Rating Scale in the investigated groups

with $p = 0.05$ considered as significant. The assessment of a physiotherapist revealed that before starting the treatment session, mean pain intensity was 6.17 ± 1.80 in group A and 6.33 ± 1.74 in group B as measured with NPRS, while at the end of the 4th week, mean pain intensity was reduced in both groups: to 2.27 ± 1.17 in group A and 4.00 ± 1.37 in group B. Table 2 shows that both techniques were effective for managing the patients but group A exhibited more remarkable results as compared with group B.

The secondary outcome that comprised subscales of psychosocial adjustment was assessed with TAPES. The assessor discovered that overall, the amputees in the experimental group adjusted psychosocially better than the control group. The experimental group patients showed a significant improvement of scores on the subscales of general adjustment and adjustment to limitation as compared with the control group; on the other hand, both groups demonstrated no considerable improvement on the social adjustment subscale of TAPES.

As for the prosthesis satisfaction subscale, a significant improvement was observed within the groups in the functional and aesthetic subscales; there was no significant difference between the control and experimental groups. Moreover, no significant difference was demonstrated during the 4 weeks of treatment in any group with reference to the prosthesis weight subscale. There was no significant effect of treatment within any group in the different follow-up periods.

Irrespective of the group, the NPRS score for PLP showed a significant linear improvement from baseline till the last follow-up ($p = 0.000$); groupwise NPRS score also exhibited a linear improvement ($p = 0.001$) (Figure 2). For between-subject effects, a significant difference was seen in the NPRS score for PLP in the investigated groups ($p = 0.042$).

Discussion

The single-blind randomized controlled trial was conducted to assess the effect of MT upon phantom pain and adjustment of lower limb prosthesis wearers to the psychosocial environment. In the current study, MT along with routine physical therapy resulted in improved PLP as compared with routine physical therapy alone. In addition, MT provided better psychosocial adjustment and higher prosthesis satisfaction.

PLP is prevalent among amputees and an effective treatment to manage PLP is still lacking. MT has been recognized as a leading alternative for PLP management, and many experimental studies have been conducted to investigate the method [36–38]. In addition, MT provides an opportunity for amputees to manage PLP themselves; it may prove to be inexpensive, alleviate pain, and increase the patient's sense of control regarding their health condition [38]. Most of the studies regarding MT effectiveness consist of uncontrolled trials with small sample sizes and heterogeneous methods, without comparison of the protocols. Furthermore, the efficacy of MT in terms of psychosocial adjustment to amputation has not been investigated to date [39].

The patients in this study practised MT 5 days a week for 4 weeks along with routine physical therapy. The treatment gave them the ability to manage and control their PLP. Supporting the researchers' method, a study revealed that 100% of individuals who had not been able to control or manage PLP reported a decrease in PLP after 4 weeks of MT therapy [36].

In several randomized controlled trials, the intensity of PLP among patients in MT groups decreased significantly more than in control groups [30, 36, 40]. The current randomized clinical trial of 36 subjects demonstrated a clinically significant mitigation in PLP intensity in the MT group ($n = 18$). The participants in both groups reported reduction in pain but between-group comparisons at follow-up time points showed that the intensity of pain significantly reduced in the intervention group compared with the control group; this was attributed to the effects of visual stimuli provided by MT in patients while performing exercises. The results of this study are in line with those presented for the previous one.

The outcome of this study implies that MT used along with routine physical therapy reduced PLP. Pain intensity was also reduced in the other group, in which routine physical therapy was applied. In a previous study, the participants reported that they perceived pain in the amputated limb at the time they retained the same position for a longer period and that limb movement during exercise reduced the intensity of pain owing to muscle relaxation [26].

In the study group, the participants who received MT along with routine physical therapy indicated better adjustment to limitation and better general adjustment after 4 weeks of treatment as compared with the control group, who underwent routine physical therapy only; so, a noteworthy between-group variance was seen. This is consistent with the results achieved by Desmond et al. [41], who revealed variance between those who perceived pain and those who did not in the earlier week of evaluation in the domain of adjustment to limitation [41].

In order to improve the quality of rehabilitation programs for amputees with PLP, MT should be widely suggested as first line treatment and should be added in primary healthcare programs for new amputees as it is easy to practise. The concept of MT should be utilized and supported by healthcare teams of diverse disciplines, such as nursing, psychiatry, prosthetics, and orthotics. It is also recommended that clinicians plan group training sessions to help maintain the patients' motivation to continue MT. It has also been proved that a single session of MT alone is not enough to gain significant results; MT should be therefore applied in combination with routine physiotherapy.

Conclusions

The amputees with PLP who received MT demonstrated a better response to the given treatment. MT in addition to routine physical therapy is a beneficial approach and shows better results towards mitigating PLP and improving amputees' psychosocial adjustment to the prosthesis as compared with routine physical therapy alone. MT yielded effective out-

comes in amputees and prosthesis users after 4 weeks of rehabilitation as it is a very practical and comprehensive method. The research performed under daily clinical illnesses supports MT application for PLP management in lower limb amputees using prostheses and suggests that physiotherapists should use MT combined with routine physical therapy as a first line treatment.

Clinical message:

– MT was found effective in the reduction of PLP when used along with conventional physical therapy in patients with amputation and prostheses.

– Amputees adjusted significantly better to amputation and prosthesis in response to MT owing to PLP reduction.

– MT combined with routine physical therapy performed 5 days a week for 4 weeks appeared a successful treatment protocol in reducing PLP.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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