The influence of virtual reality approach on phantom pain in trans-tibial amputation: A randomized control trail

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Abstract---Background Phantom limb pain (PLP): is a common complaint after lower limb amputation can be defined as discomfort or pain in a missing part of the limb. This study was conducted in the research laboratory section, Faculty of Physical Therapy, Cairo University, Giza, Egypt. Purpose: To investigate the effect of Virtual reality (VR) on phantom limb pain and lower limb Function in trans tibial amputation Methods sixty patient with phantom pain after trans tibial amputation from both genders were enrolled into 2 equal groups: a study group and a control group, with mean values of age of the study and control groups (28.73 ± 5.90) and (28.73± 6.29) years respectively, Hight (168.40±5.66) and (167.90 ±5.25) cm , wight (64.76±7.13) and (64.23±6.94) kg and of BMI (22.82 ±1.66) and (22.77±1.67) kg/m2 respectively. Outcome measures included pain intensity level was measured by McGill pain questionnaire and Lower Extremities Function was measured by Lower Extremities Function Scale. That were assessed at baseline and 4 weeks postintervention. Results A statistically significant effect (p < 0.0001) of treatment and time was revealed in both groups for all measured variables. Between-group analysis implied a higher improvement in post-intervention results in group B (p < 0.05). Conclusion This study indicated that Using VR with conventional treatment is more effective in case of Phantom pain in trans-tibial amputation that in improving pain

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intensity level (reduce pain) and Lower Extremities Function than conventional treatment alone.

Keywords---Phantom Pain, Trans-tibial amputation, phantom exercises, Mirroring therapy and Virtual Reality.

Introduction

Pain management has become an increasingly important healthcare concern in clinical practice [1] We use the phrase "phantom nerve pain" for pain described by patients related to the absence of sensation. Though simple numbness is often well-tolerated and not bothersome, phantom nerve pain develops for some patients [2]. The painful area is essentially numb yet painful, hence the term "anesthesia dolorosa," which translates as "painfully numb." In a similar way to amputees who have phantom limb pain (PLP) in a limb no longer present, patients with peripheral nerve injury can have phantom nerve pain in the denervated area. We hypothesize that damage to the peripheral first-order neurons, along with spontaneously firing second-order neurons (deafferentation), causes this pain and, if not treated in a timely manner, results in cortical remodeling and centrally mediated pain (as in phantom limb pain) [3].

Phantom limb pain (PLP) is experienced by 65–85% of limb amputees [4] In addition, a range of other sensations can originate in the missing limb including phantom limb awareness, phantom sensations (such as itching and pins and needles), and kinetic and kinesthetic sensations (movement and position in space). Traditionally the treatment target has been PLP; however, it has become clear over many years that treatment options have limited success [5].

Although in many cases these phenomena do not cause suffering, phantom limb distortions often co-occur with phantom limb pain (PLP) [6], in other words, a painful sensation located in the phantom and thus outside the physical borders of the body. PLP is reported by many amputees [7], accounts for a significant reduction in health-related quality of life and only insufficiently responds to conventional pharmacological interventions [5].

The large variation in symptomatology suggests a multifactorial origin of phantom phenomena. It has been shown that the amputation induces negative effects on peripheral and central physiological mechanisms, both contributing to the experience of phantom phenomena including PLP [8]. The two most common types of Lower limb Amputation (LLAs) are transfemoral amputation (TFA) and transtibial amputation (TTA). TFAs make up 31% of all amputations, and TTAs make up 39% of all amputations [9].

Virtual Reality (VR) is characterized by an artificial computer-generated environment created to replace real-world sensory inputs [10]. It uses a computer to generate a simulation environment, which the users interact with, providing an immersive experience that facilitates the perception of being physically present in the virtual environment [11]. In recent years, with the advent of more affordable devices such as head-mounted displays, VR has become a more feasible and

popular technology [12] Unlike many analgesics, which disrupt the C-fiber pathway that relays nociceptive signals to the central nervous system, VR affects pain perception through attention, concentration, and emotional alteration [13]. The immersive environment created by VR reduces pain experience by up regulating nonpainful neural signaling [14]. Increasing evidence supports VR as an alternative strategy for acute, burn, and experimental pain management in both adults and children [15] Additional experiments have demonstrated the positive effect of VR on pain in a variety of medical procedures including chemotherapy and wound care [16]. With immersive technology, participants view the full panorama, which enables the creation of a high sense of presence and immersion as if the participant is essentially inside the created environment [17].
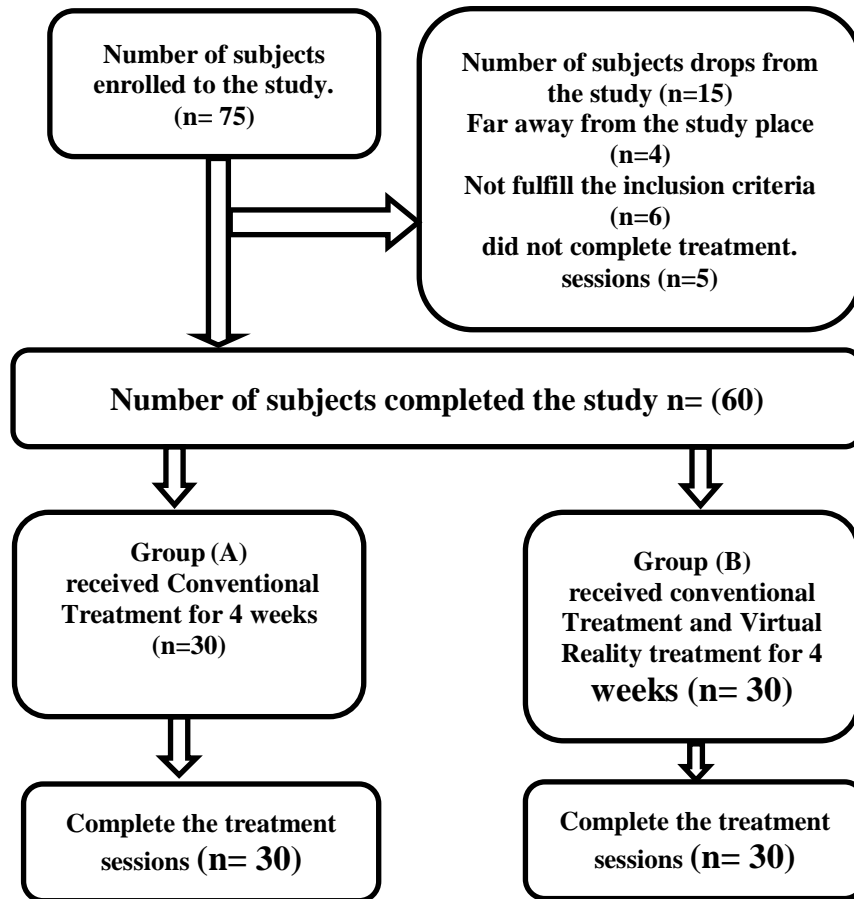
One of the strategies for the management of PLP is phantom motor execution (PME), also known as phantom exercises. PME involves the imaginary movement of phantom limb in the brain along with the performance of certain actual physical movements. Neurophysiological networking involved in PME is like that of actual executed physical activities of sound limb and it should be distinguished from pure imaginary activities as it follows a different neurophysiological pathway [18]. Such exercises have been shown to safely and effectively relieve PLP in various types of limb amputations [19] For instance, the effectiveness of phantom exercises – versus general exercises - was evaluated in post-traumatic lower limb amputees. A Significantly greater reduction in pain was observed because of phantom exercises [20].

According to the literature, there is a gap of knowledge around using VR to reduce phantom pain in trans tibial amputation. The study aimed to investigate the effect of VR on phantom limb pain and lower extremity function in comparison to the conventional physical therapy (Mirroring therapy, phantom exercises and TENS).

Subjects, Materials and Methods

Design:
Pretest-posttest Randomized Controlled clinical trial.

Subjects:

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┌─────────────────────────┐      ┌──────────────────────────────┐
│   Number of subjects    │      │  Number of subjects drops from │
│  enrolled to the study. │──────│       the study (n=15)         │
│        (n= 75)          │      │  Far away from the study place │
└─────────────────────────┘      │           (n=4)                │
                                 │  Not fulfill the inclusion     │
                                 │       criteria (n=6)           │
                                 │  did not complete treatment.   │
                                 │       sessions (n=5)           │
                                 └──────────────────────────────┘
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Number of subjects completed the study n= (60)

| Group (A) received Conventional Treatment for 4 weeks (n=30) | Group (B) received conventional Treatment and Virtual Reality treatment for 4 **weeks (n= 30)** |

| Complete the treatment sessions **(n= 30)** | Complete the treatment sessions **(n= 30)** |

Sixty participants from both genders with phantom limb pain after trans tibial amputation were assigned into 2 equal groups, Control group (GA) (n = 30; 18 male and 12 female) and Experimental group (GB) (n = 30;21 male and 9 female). The mean values of age of the control and experimental group (28.73 ± 5.90) and (28.73± 6.29) years respectively, Height (168.40±5.66) and (167.90 ±5.25) cm, weight (64.76±7.13) and (64.23±6.94) kg and of BMI (22.82 ±1.66) and (22.77±1.67) kg/m2 respectively.

Inclusion criteria:
1. All participants were prescreened older than 18 years; able to provide informed consent; with unilateral traumatic Factors Phantom Limb Pain lower limb amputation after complete recovery [21].
2. Chronic PLP for more than 3 months [21].
3. If the subject was taking any medications, dosages must have been stable for at least 2 weeks before enrollment in the study [21].
4. Ormal Body mass index ranged from 18.5 to 24.9[22].

Exclusion criteria:
1. History of alcohol or drug abuse within the past 6 months [21]
2. Medical history of photophobia, epilepsy or any other light sensitivity [23].
3. Visual impairment thought to render the test invalid (people who need to wear glasses day to day are not excluded [23].
4. Uncontrolled epilepsy or prior seizures within the past year [21].
5. History of unexplained fainting spells or loss of consciousness as self-reported during the past 2 years [21].
6. Mirror therapy within 3 months prior to enrollment [21].

Scales and Instrumentation for assessment:

Each subject was assessed for Phantom Pain and Lower Extremity Function, Pain intensity level using The McGill Pain Questionnaire and Lower Extremity Function using Lower Extremity Function Scale.
Instrumentation for Assessment:
A. Health weight and height scale.
B. McGill Pain Questionnaire.
C. Lower Extremity Functional Scale (LEFS).

A. Health weight and height scale:

Calibrated floor health scale ZT-120 model Figure (1). Health scale was used to measure the weight of each participant in kilograms and height in centimeters to calculate body mass index for each subject before each experiment, BMI was calculated using following formula:

$$\text{BMI} = \frac{\text{weight (KG)}}{\text{height squared } (m^2)}.$$

Figure 1. Calibrated floor health scale

B. McGill Pain Questionnaire:

McGill Pain Questionnaire which was developed as a multidimensional measure of perceived pain among adults with chronic pain [24] The McGill Pain Questionnaire was introduced in 1975 and includes 78 words related to sensory, affective, evaluative, and miscellaneous pain subscales [24] The McGill Pain Questionnaire was the first measure of multiple dimensions of pain; previous scales had focused only on pain intensity. The Short Form McGill Pain Questionnaire (SF-MPG) was subsequently developed in 1987 and includes pain rating items related to sensory and affective subscales of pain Modified of McGill Pain Questionnaire. The McGill Pain Questionnaire. The descriptors fall into four major groups: sensory (S)1-10, affective (A) 11-15, evaluative (E), 16 and miscellaneous (M)17-20. The rank value for each descriptor is based on its position in the word set. The sum of the rank values is the pain rating index (PRI). The present pain intensity (PPI) is based on a scale of 0-5 [25].

C. Lower Extremity Functional Scale (LEFS):

The objective of the Lower Extremity Functional Scale (LEFS) is to measure "patients' initial function, ongoing progress, and outcome" for a wide range of lower-extremity conditions [26] It is divided to 5 categories; 0 indicates extreme difficult or unable to perform activity, 1 indicates quite a bit of difficulty, 2 indicates moderate difficulty, 3 indicates a little bit of difficulty, 4 indicates no difficulty [26].

Control group (GA): The Conventional physical therapy program

1- Mirroring Therapy:
MT consists in placing a mirror in the parasagittal plane between the healthy limb and the amputated limb. The image of the healthy limb is reflected in the mirror and the patient perceives the reflection of the healthy limb instead of the amputated limb. By creating a visual representation of the missing limb, MT might restore the cortical (motor and sensory) areas that correspond to the absent limb. By restoring the body image and body schema disturbed by the amputation, MT might reduce PLP [27-28-29].
This visual feedback is thought to reactivate brain areas responsible for the missing limb, potentially restoring its representation and reducing the discomfort of PLP. Essentially, MT aims to heal the brain's image of the body, which might in turn alleviate the pain associated with the missing limb. (Figure 2)

Figure 2. Mirroring exercise

2- Phantom Exercise:

One of the less investigated strategies for the management of PLP is phantom motor execution (PME), also known as phantom exercises. PME involves the imaginary movement of phantom limb in the brain along with the performance of certain actual physical movements. Neurophysiological networking involved in PME is like that of actual executed physical activities of sound limb and it should be distinguished from pure imaginary activities as it follows a different neurophysiological pathway [18] Such exercises have been shown to safely and effectively relieve PLP in various types of limb amputations [19]. For instance, the effectiveness of phantom exercises – versus general exercises - was evaluated in post-traumatic lower limb amputees. A Signifcantly greater reduction in pain was observed because of phantom exercises [20]. The patients were asked in which position they felt the phantom limb, and instructed to keep that position, to place the intact limb in the same position as their phantom limb, to move both limbs in opposite directions, and to return them to the starting position again. The patients were asked to repeat these movements a couple of times. (Figure 3)

Figure 3. Phantom exercise

3- Transcutaneous electrical nerve stimulation (TENS):

This is a battery-operated device that sends out an electrical current of charged particles through adhesive pads that are placed on the skin, these electrical impulses can help reduce pain through the gate-control theory of pain. This theory is focused on the idea of activating non-nociceptive, or non-painful, nerves and inhibiting nociceptive signals in the spinal cord, Therapeutic use of TENS is usually categorized as high rate or low rate, each distinguished by a change in frequency. Frequency refers to the number of electrical impulses per second [30].

TENS stimulation plays on pain gate theory it sends stimulation to close C-fibers to relieve the pain and make the patient comfortable. The electrodes were put around the stump leg (residual limb) and the session lasts for 15 minutes, the parameters were Conventional TENS – high frequency (50–100 Hz), low intensity, short pulse width (50–200 µs). Pain relief by means of the pain gate mechanism involves activation (excitation) of the A beta (Aβ) sensory fibers, and by doing so, reduces the transmission of the noxious stimulus from the 'c' fibers, through the spinal cord and hence on to the higher centers. (Figure 4)
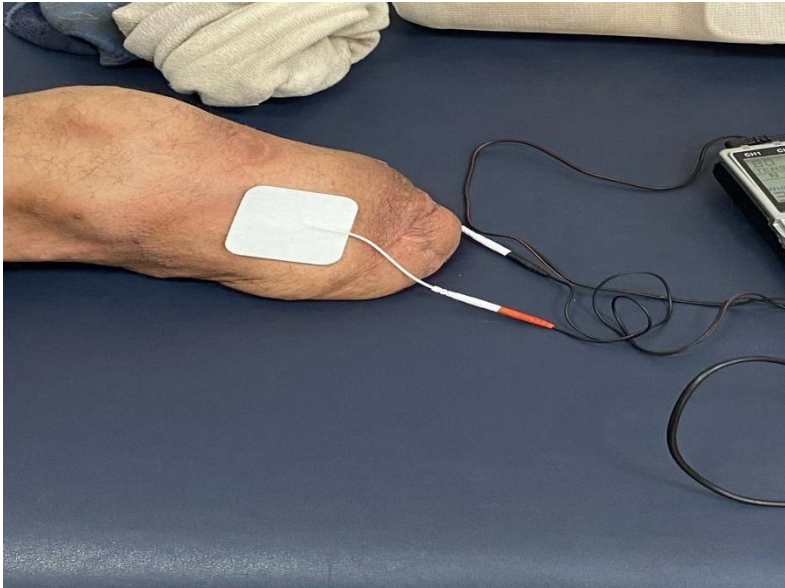
Fig4 TENS modulation

-Experimental group (GB): The Conventional physical therapy program and the VR approach.

This group will receive conventional physiotherapy (Phantom exercise, Mirroring Exercises, Transcutaneous electrical nerve stimulation (TENS) In addition to the new technology in treatment VR approach.

With immersive technology, participants view the full panorama, which enables the creation of a high sense of presence and immersion as if the participant is essentially inside the created environment [17]. With VR, participants view the full panorama, which enables the creation of a high sense of presence and immersion as if the participant is essentially inside the created environment [17]. Computer simulation system that allows users to experience virtual world [31]. The setup consisted of the console (Xbox 360®), a motion sensor (Kinect®), and a projector with speakers. The height of the console, which was placed on a table, was 1 m. The Kinect® motion sensor was placed on the projector, which projected images on a wall located 2.5 m away from the playing area. The playing area was at least 1.8 m wide and 1.8 m long and was located 1.2 m from the Kinect® sensor. Before starting each training session, the device was calibrated to correctly follow the movements of each patient the intensity-controlled VR sessions included games provided by the Kinect® Adventures (Microsoft Game Studios, Washington, US). Patients participated in mini games in which they performed certain movements in front of the motion sensor. The games included rafting, cross-country running, hitting a ball in the direction of a player on the screen, and a mountain wagon ride. Before each game, the manufacturer's instructions were displayed, indicating the goal of the game and the method of the avatar control. Kinect® training involved four games: 20,000 Leaks, Curvy Creek, Rally Ball, and Reflex Ridge. The VR treatments were applied for 30 minutes / session / 3 times a week. Each patient uses the VR for 3 games or more and the whole aim of these

games is to reduce phantom limb pain, increase lower Extremities function and balance. The VR training was supervised by a physiotherapist. [32] (Figure5,6).

Figure 5. Amputee patient uses VR game

Figure 6. Amputee patient uses VR game

Ethical approval

The study protocol was approved by the Research Ethical Committee of the Faculty of Physical Therapy (P.T.REC/012/004810) and registered in ClinicalTrials.gov as well (NCT06262503). Before participating in this study, a written consent form was signed down by each subject.

Statistical Analysis:

The collected data will be statistically analyzed using:
- Descriptive statistics (mean and standard deviations).
- Inferential statistics: ANOVA will be used to compare subject's characteristics of the two groups. MANOVA will be used to compare parametric variables within and between groups.
- Statistical analysis will be conducted using SPSS for Windows, version 20 (SPSS, Inc., Chicago, IL). Statistical significance will be set at the ($p < 0.05$).

Results

Sixty patients from both sexes participated in the study; they were randomly assigned to control group (Group -A, n=30) included Phantom Pain in Amputee patients who received selected physical therapy

programs and experimental group (Group-B, n=30) included 30 Phantom Pain in Amputee patients who virtual reality (VR) in addition to the same selected physical therapy program.

1. Demographic characteristics of the participants:

The demographic characteristics of participants in each group are represented. In group A: the mean Age, height, weight and BMI were 28.73 ± 5.90, 168.40±**5.66**cm, 64.76±**7.13** kg, 22.82 ±1.66 kg/m², respectively. Whereas, in group B: the mean age, height, weight and BMI were 28.73± 6.29, 167.90 ±5.25cm, 64.23±**6.94** kg, and 22.77±**1.67** kg/m² (Table 1 and Figure 7). No significant differences were found between both groups regarding mean of BMI, height, and weight (p>0.05). Regarding sex distribution, control group included 60% males and 40% females & experimental group included 70% males and 30% females.

Table 1: Demographic characteristics of the patients in both groups

Variables	Group-A	Group-B	
	Mean ± SD	Mean ± SD	P-Value
Height (cm)	168.40 ± 5.66	167.90 ± 5.25	.724
Weight (kg)	64.76 ±7.13	64.23 ± 6.94	.770
BMI (kg/m²)	22.82 ± 1.66	22.77 ± 1.67	.909
Age	28.73 ± 5.90	28.73± 6.29	.310
Sex	n (%)	n (%)	
Male	18 (60%)	21 (70%)	
Female	12 (40%)	9 (30%)	

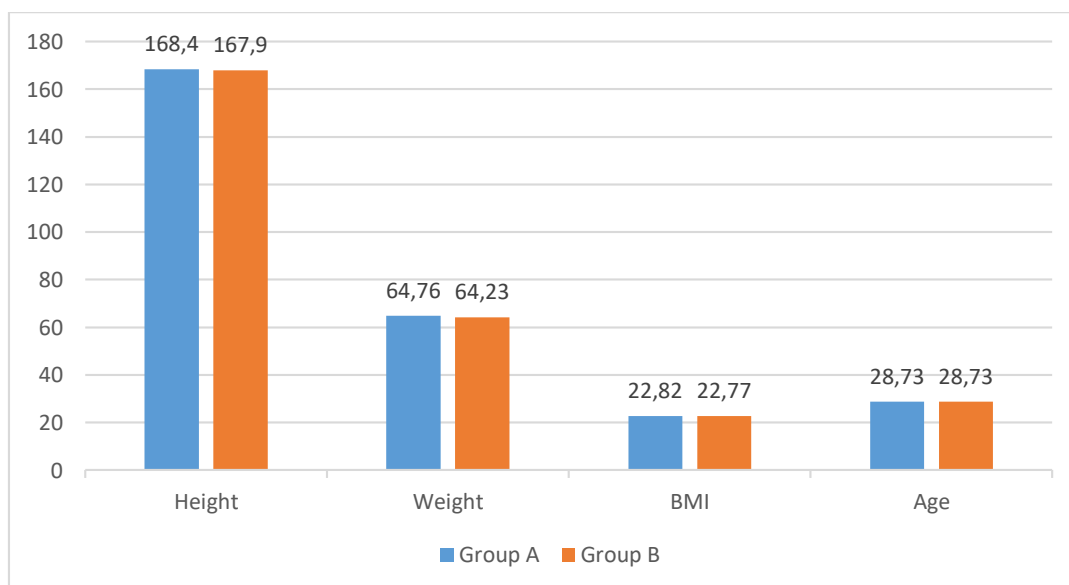*Significance (p<0.05), SD- Standard Deviation, BMI- Body Mass Index

Figure (7). Demographic characteristics of the patients in both groups

Comparative results:

2. Pain Rating Index:

There was a significant change in both groups as regards mean values of Pain Rating Index (PRI) post treatment (p < 0.001). The results of Paired Samples Test being significant at p < 0.001 would indicate significant interaction between and within groups.

Within-group comparisons:
The mean values of Pain Rating Index post treatment (PRI) of group A before and after treatment were [18.46±1.14] and [15.8±0.96] respectively. The mean difference (MD) was= 2.66; the percentage change was 14.4%. There was a significant change in Pain Rating Index post treatment (PRI) in group A after treatment (p< 0.001).
The mean values of Pain Rating Index post treatment of group B before and after treatment were [18.36±1.13] and [14.03±0.96] respectively. The mean difference (MD) was= 4.33; percentage change was 23.58%. There was a significant change in Pain Rating Index post treatment (PRI) in group B after treatment (p< 0.001). (Table 2 and Figure 8).

Table 2: Comparison of mean values of PRI within and between groups

Pain Rating Index (PRI)		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	G A _pre - G A_post	2.66667	.75810	.13841	2.38359	2.94975	19.267	29	.000
Pair 2	G B _pre - G B _post	4.33333	.71116	.12984	4.06778	4.59888	33.375	29	.000
Pair 3	G A _pre - G B _pre	.10000	.54772	.10000	-.10452	.30452	1.000	29	.326
Pair 4	G A_post - G B _post	1.76667	.81720	.14920	1.46152	2.07181	11.841	29	.000

*Significance (p<0.05); df: independent values

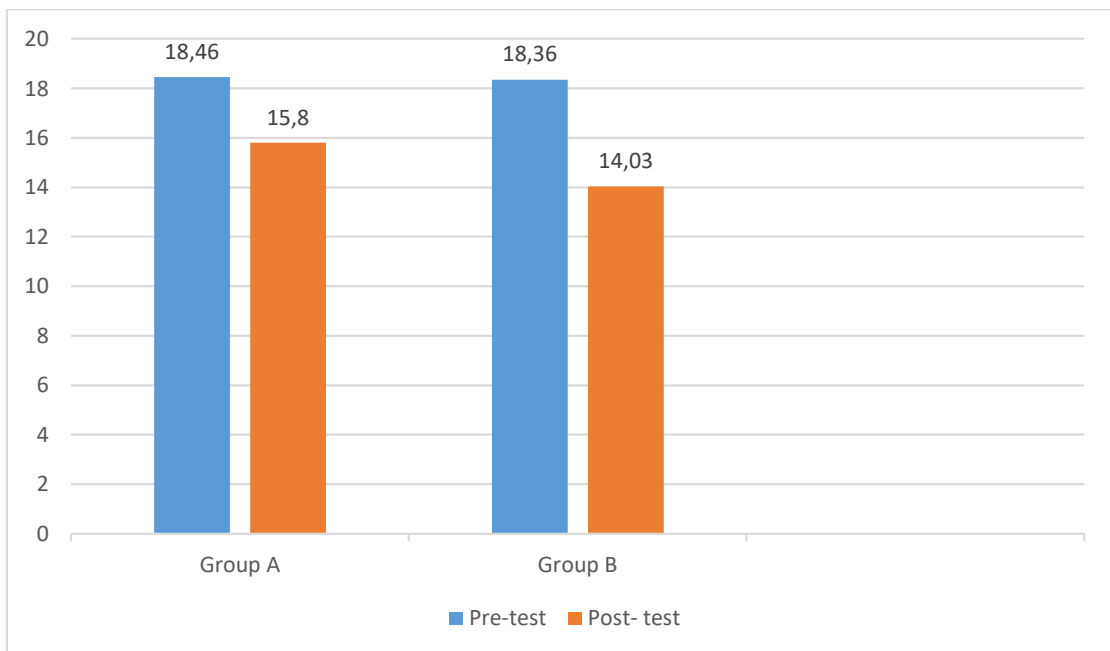Figure (8). Comparison of mean values of PRI within both groups

Between-group comparisons:

There was no significant difference between the two groups in the mean values of Pain Rating Index before treatment. While there was a significant difference between both groups after treatment [MD: 1.76; CI: 1.46 to 2.07; p<0.001] with more significant difference in group B (P=0.000) (Table 2 and Figure 9).
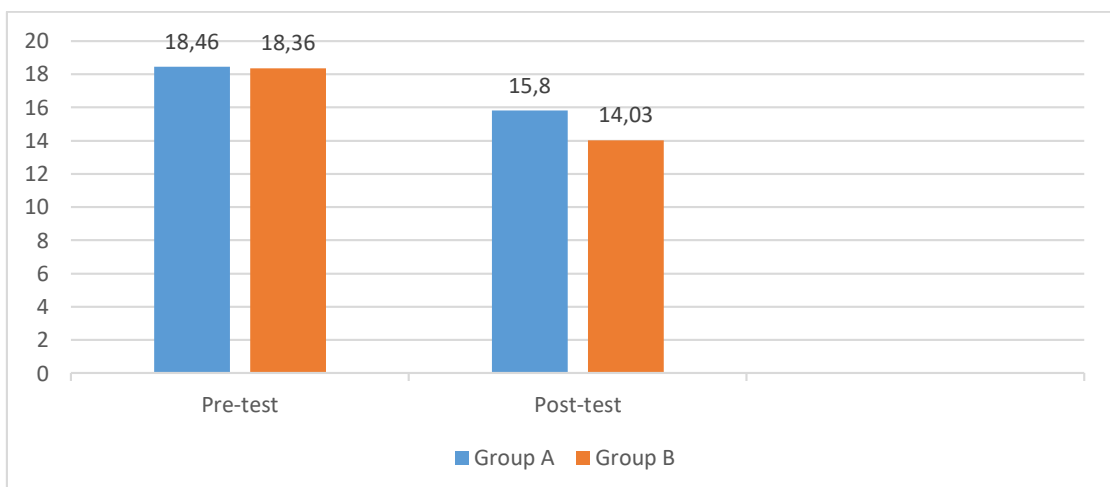

Figure (9): Comparison of mean values of PRI between both groups.

3. The present pain intensity:

There was a significant change in both groups as regards mean values of the present pain intensity (PPI) post treatment (p < 0.001).
The results of Paired Samples Test being significant at p < 0.001 would indicate significant interaction between and within groups.

Within-group comparisons:
The mean values of the present pain intensity (PPI) of group A before and after treatment were [4.33±**0.11**] and [3.50±0. 68] respectively. The mean difference (MD) was= 0.83; the percentage change was 19.16%. There was a significant change in present pain intensity (PPI) post treatment in group A after treatment (p< 0.001).
The mean values of present pain intensity (PPI) post treatment of group B before and after treatment were [4.27±0.64] and [2.80±0. 61] respectively. The mean difference (MD) was= 1.46; percentage change was 34.42%. There was a significant change in present pain intensity (PPI) post treatment in group B after treatment (p< 0.001). (Table 3 and Figure 10).

Table 3: Comparison of mean values of PPI within and between groups

| | | Paired Differences | | | | | | |
| | | | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | | | |
The present pain intensity (PPI)	Mean				Lower	Upper	t	df	Sig. (2-tailed)
Pair 1 **G A _pre - G A _post**	.83333		.59209	.10810	.61224	1.05442	7.709	29	.000
Pair 2 **G B _pre - G B _post**	1.46667		.68145	.12441	1.21221	1.72112	11.789	29	.000
Pair 3 **G A _pre - G B _pre**	.06667		.52083	.09509	-.12781	.26115	.701	29	.489
Pair 4 **G A _post - G B _post**	.70000		.79438	.14503	.40337	.99663	4.826	29	.000

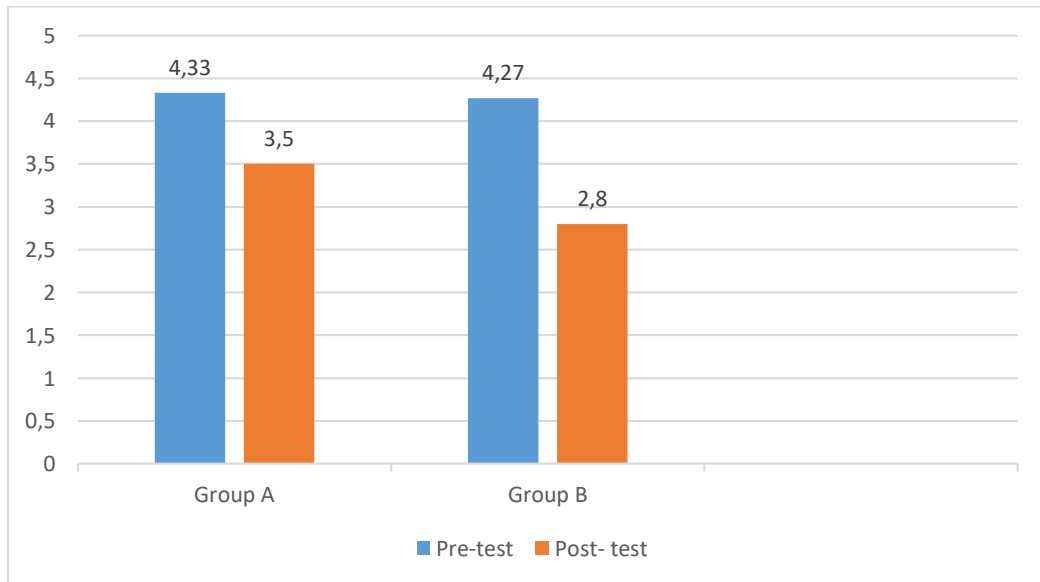*Significance (p<0.05); df: independent values

Figure (10): Comparison of mean values of PPI within both groups

Between-group comparisons:

There was no significant difference between the two groups in the mean values of present pain intensity before treatment. While there was a significant difference between both groups after treatment [MD: 0.70; CI: 0.40 to 0.99; p<0.001] with more significant difference in group B (P=0.000) (Table 3 and Figure 11).
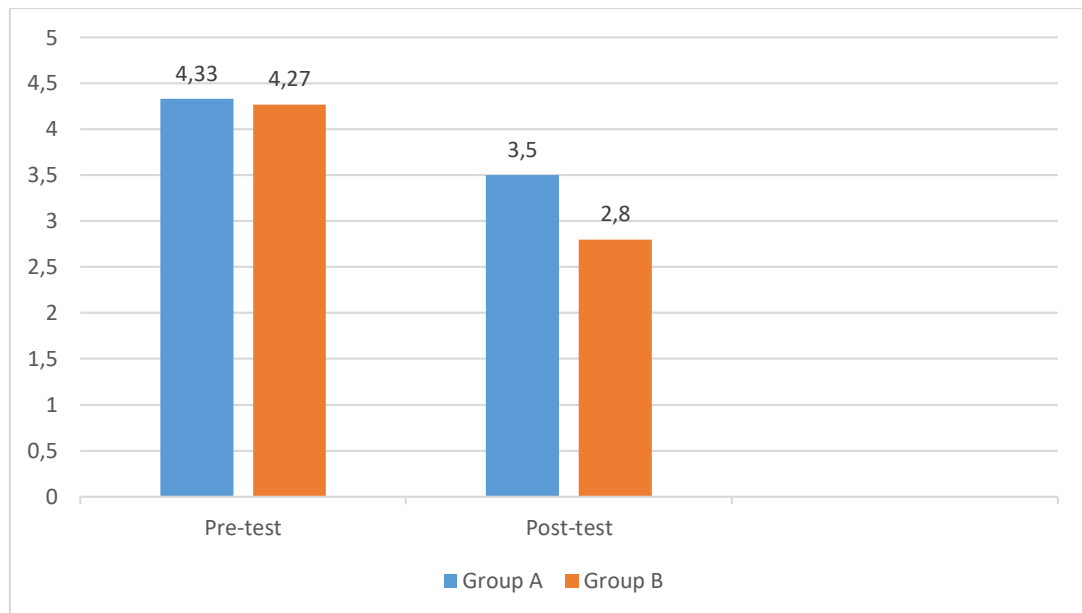

Figure (11). Comparison of mean values of PPI between both groups

4. Lower Extremity Functional Scale:

There was a significant improvement in both groups as regards mean values of the Lower Extremity Functional Scale post treatment (p < 0.001).
The results of Paired Samples Test being significant at p < 0.001 would indicate significant interaction between and within groups.
Within-group comparisons:
The mean values of the Lower Extremity Functional Scale of group A before and after treatment were [22.67±2.23] and [35.47±3.96] respectively. The mean difference (MD) was= -12.80; the percentage change was 56.46%. There was a significant improvement in Lower Extremity Functional Scale post treatment in group A after treatment (p< 0.001).
The mean values of Lower Extremity Functional Scale post treatment of group B before and after treatment were [23.23±1.85] and [46.30±6.01] respectively. The mean difference (MD) was= -23.06; percentage change was 99.3%. There was a significant improvement in Lower Extremity Functional Scale post treatment in group B after treatment (p< 0.001). (Table 4 and Figure 12).

Table 4: Comparison of mean values of Lower Extremity Functional Scale within and between groups

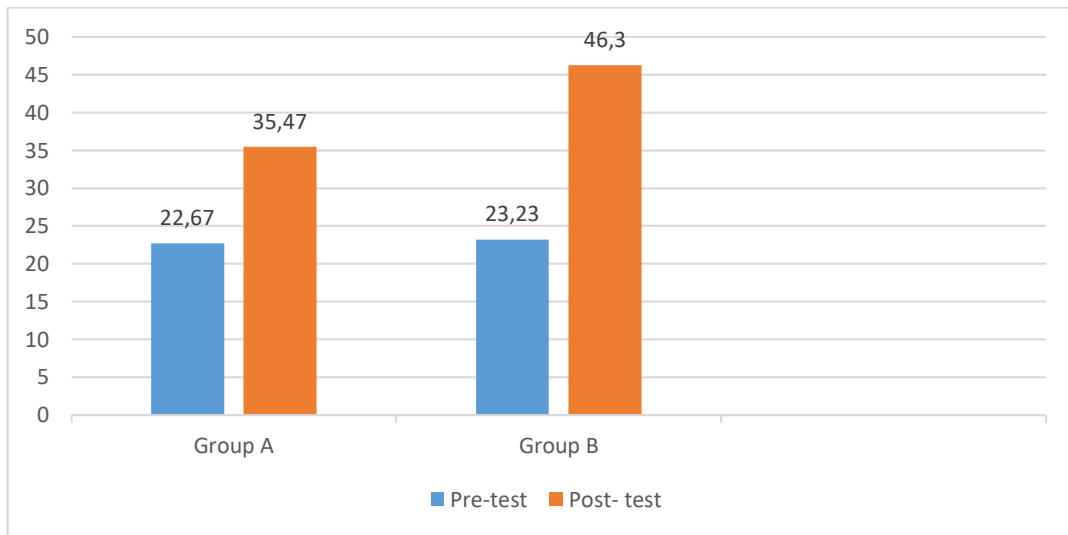| Lower Extremity Functional Scale	Paired Differences							
		Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
	Mean			Lower	Upper			
Pair 1 **G A _pre - G A _post**	-12.80000	3.06707	.55997	-13.94526	-11.65474	-22.858	29	.000
Pair 2 **G B _pre -G B _post**	-23.06667	6.12476	1.11822	-25.35369	-20.77964	-20.628	29	.000
Pair 3 **G A _pre - G B _pre**	-.56667	1.54659	.28237	-1.14417	.01084	-2.007	29	.054
Pair 4 **G A _post - G B_ post**	-10.83333	5.69987	1.04065	-12.96170	-8.70497	-10.410	29	.000

*Significance (p<0.05); df: independent values

Figure (12). Comparison of mean values of Lower Extremity Functional Scale within both groups

Between-group comparisons:

There was no significant difference between the two groups in the mean values of Lower Extremity Functional Scale before treatment. While there was a significant difference between both groups after treatment [MD: -10.83; CI: -12.96 to -8.70; p<0.001] with more significant difference in group B (P=0.000) (Table 4 and Figure 13).
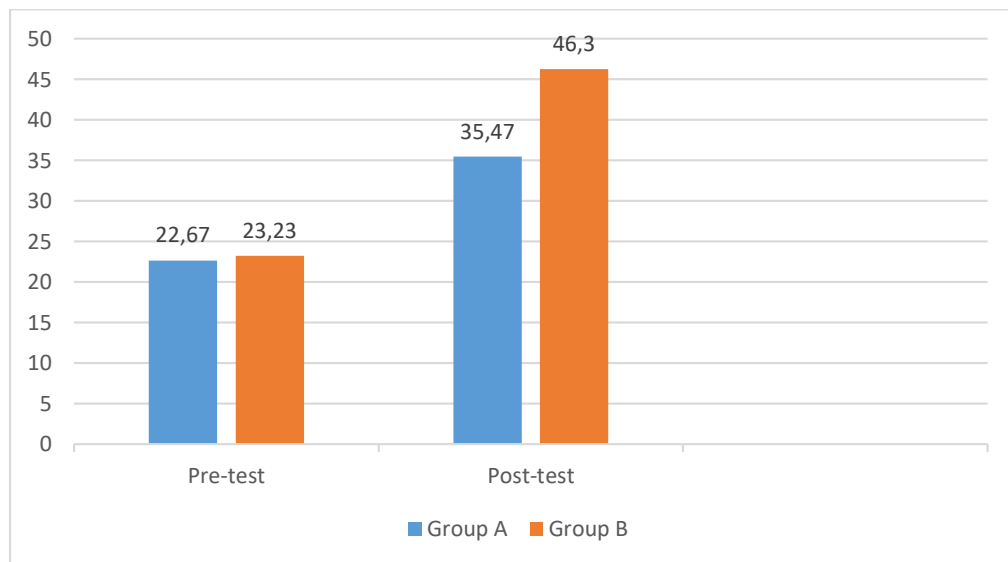
Figure (13). Comparison of mean values of Lower Extremity Functional Scale between both groups

Discussion

In this study, we found that both Virtual Reality treatment plus traditional treatment (Mirroring therapy, Phantom exercise and TENS) and traditional treatment only had a good effect on phantom pain and lower extremity function, improved in both groups who received treatment, but we noticed that the group that received Virtual Reality treatment plus traditional treatment improved by a greater percentage than the group that received traditional treatment only. This was in relation to phantom pain and lower extremity function.

We expect this improvement to the physiological and psychological effect that the (VR) treatment; as it immersive the patient in a virtual reality and the avatar of the patient have all of his four limbs and the patient can see his four limbs, move with them, play with them and achieve every mission in all the games so he forgot about his phantom pain and improve hi lower limb function.

Ambron E et al [33] agreed with us that VR intervention comprising a combination of distractor and active limb treatments was successful in reducing lower-limb PLP in most participants. Group analyses showed a reduction of pain on our primary outcome measure after both treatments. Individual analyses demonstrated that the limb therapy was superior to distractor treatment in one subject, but the two treatments did not differ in other subjects.

In line with our study Lendaro et al [34], they found a 68% progressive reduction in PLP across 12 weeks of VR treatment that remained evident at 1- and 3-months follow-up but not at 6 months. The treatment consisted of a set of motor exercises to be executed in VR in which measurements from surface electromyography controlled the motions of a visually displayed limb, which caused subjects to feel as though they were controlling their missing leg. We

chose a magnetic motion-tracking system over electromyography to simplify system setup and more accurately display real limb movements in VR.

In a small-scale pilot study Kulkarni J et al [23] focusing on the effects of VR on PLP with an attempt to identify aspects within amputees which may help to decide who may benefit from VR therapy. the quantitative findings are supported generally by the qualitative results. In the main the participants considered VR to have some benefits including a reduction in PLP during and after the VR exercise. Most requested more sessions and by implication, this suggests that we have not identified what might be termed a dose of VR therapy. It does appear that the effects of VR wear off over time as the PLP intensity had almost returned to baseline at the one-year point. Our equipment was fixed and only able to be used in the department so future studies should consider supplying equipment and allowing participants to use it at home as and when PLP is present. All the patients indicated that they would have liked to continue using a portable version of Immersive VR set up, at home for a prolonged period.

Thomas Rutledge et al [35] report described the results of a two-phase feasibility study designed to a) develop a customized VR treatment for PLP and b) test the intervention, including the feasibility, acceptability, and effects of the treatment on PLP and phantom sensations. Use of the VR treatment was associated with statistically significant reductions in PLP intensity and phantom sensations. These benefits were present among both initial and repeat users of the treatment. Participants similarly rated the VR treatment high on the dimensions of immersion, realism, helpfulness, satisfaction, and fun.

In this study Tong, Xin, et al [36] Our data here also showed an improvement in movements of a phantom limb, quantified as a reduction in motor imagery time that was specific to the impaired limb. Given that the motor imagery was measured only twice, we believe that the practice effect alone could not explain the large and limb-specific effect. The observed 60.59 and 66.53% reduction in imagery time in the two motor tasks was remarkable because it dropped to levels comparable to that of the intact limb. The improvement suggests better control of the impaired limbs' movement.

Osumi et al [37] used a bimanual coupling effect between the affected limb and the intact limb as an indirect measure of changes in phantom limb control. They found that bimanual coupling increased with VR interventions and, importantly, were correlated with the VR-induced analgesic effect.

Our findings of improved motor imagery in the affected limb are in line with Osumi et al [37] findings, suggesting that improved voluntary movement of the phantom limb might reflect the neuroplastic changes in PLP patients that are associated with VR's analgesic effects. However, we did not run a correlation analysis between the improvement in motor imagery and the analgesic effect due to the small sample size.

Finally, all studies agreed on all VR studies should contain large sample size so the researcher could have statistical analysis and the time of treatment should last from one months to six months. In our study we used VR treatment on sixty

person and treatment lasts for one month (three session per week) and we found a different in statistical analysis that VR treatment helping in reducing phantom pain and increasing lower extremity function in comparing with using traditional treatment.

Conclusion

Virtual Reality treatment plus traditional treatment (Mirroring therapy, Phantom exercises and TENS) have positive effect on Phantom pain and lower extremity function more than traditional treatment only and lead to decrease phantom pain in trans-tibial amputation and increase lower extremity function.

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