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Case Report

Self-Hypnosis for Phantom Limb Pain: A Multiple-Case Study

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Abstract

Phantom limb pain occurs in more than half of the people who have undergone an amputation. Hypnosis can alleviate pain effectively in experimental, procedural, and chronic pain. Thus, in this multiple-case study, we determined whether hypnosis might be a successful complementary approach to help patients with phantom limb pain in alleviating their pain quality (i.e., sensitive and affective), intensity, fatigue, and emotional distress (i.e., anxiety and depression). Seven patients experiencing phantom limb pain were trained to perform self-

hypnosis in five sessions over two and a half months. The patients were encouraged to practice at home daily throughout the study. Measures of the intensity of pain and fatigue, the severity of insomnia, anxiety, depression, and the quality of pain (i.e., sensitive and affective) were performed before and after self-hypnosis training. Six years after the completion of the study, the patients were contacted over the telephone to follow up on their practice of self-hypnosis. All patients reported a reduction in the intensity of pain, severity of insomnia, anxiety, and quality of pain. They also reported a positive change in their behaviors and the sensation of pain after performing hypnosis. At the six-year follow-up, three patients were still practicing hypnosis and reported better control over pain and being more relaxed. The main reason for most patients to stop practicing self-hypnosis was that they failed to find the time. Self-hypnosis can effectively ameliorate pain, fatigue, and emotional distress in patients suffering from phantom limb pain. Large-sample clinical trials with a mixed design are needed to confirm these results.

Keywords
Hypnosis; phantom limb; pain

1. Introduction

Following limb amputation, people might experience pain in the limb that no longer exists, more commonly known as phantom limb pain (PLP) [1, 2]. Amputations are mainly performed because of traumatic (e.g., traffic accidents), biological (e.g., diabetes), congenital, or infection-related [1, 3] issues. PLP occurs in 50 – 80% of cases of amputation and might appear a few days after the amputation [3-6]. This type of pain is described as boring, stabbing, throbbing, squeezing, shooting, and burning, accompanied by a sensation of temperature changes [5, 7]. It can be constant, but generally, PLP is intermittent [3, 5]. Besides these qualities of pain, people might also experience pain in the stump [8]. An amputation damages the central and peripheral nervous system, which might lead to the emergence of neuropathic pain that generally becomes chronic [9]. Thus, the primary treatments for PLP usually involve administering anti-epileptic drugs, non-steroidal anti-inflammatory drugs, tricyclic antidepressants, and opioids [1, 7]. Although these drugs seem efficacious in the short term, their long-term use, especially the administration of opioids, leads to strong side effects, such as drug misuse, dizziness, digestive reactions, and dependence [1, 10]. Complementary approaches such as mirror therapy [11], acupuncture [12], central nervous system stimulation (i.e., transcutaneous nerve stimulation and deep brain stimulation) [13, 14], high-frequency electric nerve block therapy [15], virtual reality [16], and hypnosis have been tested to treat PLP [4, 7, 17, 18]. Although these approaches were shown to be effective to some extent, more robust studies are needed to validate their effectiveness. These approaches, although complementary, require the application of external techniques or tools to treat the patients. Hypnosis, however, allows individuals to discover and use their resources and thus to be actors of their recovery. Hypnosis can also be used in other contexts or for other purposes. Thus, once mastered, it can be applied to any problem. The latter topic will be discussed in this paper.

Hypnosis is a "state of consciousness involving focused attention and reduced peripheral awareness characterized by an enhanced capacity for response to suggestion" [19]. It has four main components [20-22], which include absorption, dissociation, suggestibility, and automaticity. Absorption is the tendency to become completely involved in a perceptive or imaginary experience; dissociation corresponds to a mental separation of components of behaviors that normally would be processed together; suggestibility is the tendency to conform to the suggestions given and to suspend one's critical judgment [20]; automaticity is a non-voluntary response to a suggestion [21, 22]. A hetero-hypnosis session usually begins with a verbal induction by the therapist, followed by suggestions. During induction, the patient focuses on an object or their breathing, while the suggestions are indirect instructions given according to a goal that was mutually agreed upon [23]. In some clinical situations, the goal of hypnotherapy is to teach self-hypnosis. Self-hypnosis occurs when a person self-induces hypnosis [24, 25]. Hypnosis positively affects the management of chronic pain [26, 27]. It can improve pain, anxiety, depression, dysfunctional beliefs, and the overall quality of life in patients with chronic pain [28, 29]. Additionally, its benefits are maintained over the long term [24, 25].

Considering that PLP is a type of chronic neuropathic pain and that hypnosis significantly enhances the quality of life of patients with chronic pain, in this multiple-case study, we assessed whether self-hypnosis training might decrease the perception (i.e., sensitive and affective aspects) and intensity of pain, sleep disturbances, and emotional distress (i.e., anxiety and depression) in seven individuals suffering from PLP. We first described each case and explained the general methodology. Then, we illustrated the personalized qualitative results for each case, followed by a discussion and conclusion.

2. Materials and Methods

2.1 Patients

The patients were recruited after consulting an expert on PLP (B.M.). Out of the 100 patients contacted, only seven participated. The reasons for refusal mainly included the place and duration of the experiment, the lack of time, phantom pain of very low intensity, and no interest in the study. The patients were at least 18 years old, fluent in French, had undergone an amputation, suffered from PLP, and had the consent of their doctor to participate in this study. The exclusion criteria were as follows: any sensitivity disorders (i.e., a sensation of numbness, tingling, electric shocks, or squeezing, pain when in contact with an object, and difficulty in distinguishing hot from cold [30]), psychiatric history (i.e., schizophrenia, psychosis, borderline with prolonged dissociation episode), drug addiction, and alcoholism. All participants provided written informed consent to participate in the study.

The study complied with the Declaration of Helsinki and was approved by the Ethics Committee of the Medical School of the University of Liège, Belgium (Belgian n°: B707201629056; reference number: 2016/176).

2.2 Procedure

Each participant attended five in-person individual hypnosis sessions (with a specific goal in each session) spaced two weeks apart. Each session lasted 45 min, during which the patient performed a

hypnosis exercise of 20 min. After each session, the patient was given a CD with the hypnosis exercise performed during the session and was suggested to listen to it daily until the next session. The intensity of pain and fatigue, the severity of insomnia, anxiety, depression, and pain quality were assessed using standardized questionnaires before (T1) and after (T2) completion of the self-hypnosis training (i.e., before and after the five hypnosis training sessions). The hypnosis exercises were provided by an expert on clinical hypnosis (A.V.) and have been described in other studies [24, 31]. During the exercises, the patients were suggested to mobilize and move the phantom limb. We here propose to describe each hypnosis exercise, in addition to the mechanisms and hypotheses regarding their effects on the outcome.

In the first exercise, called "Soothing White Clouds", the therapist first asked the patients to fixate on three objects in the room. Once they found them, she suggested that they close their eyes and concentrate on three different sounds. The patients nodded their heads when they heard them. They were then asked to concentrate on three sensations in the body and nod again. The therapist constantly advised the patients to take as much time they needed. She then suggested they focus on their breathing and feel the path, the temperature, and the flow of air associated with inhalation and exhalation. She then called upon the patients' memory to make them discover a sky of a beautiful color. They were suggested to observe it, observe all the details of that place, and imagine a sunrise. They were asked to focus on the details of the landscape with the nuances of colors, the familiar sounds, or the silence. Gradually, the sky became blue, accompanied by some clouds which took the shape of an armchair. The patients had to settle down comfortably and safely. They felt comfortable in every part of their body because the chair was perfectly adapted to them. They were then suggested to discover familiar things differently from another perspective. Accompanied by other sounds, the pure air of this place re-energized them and made them comfortable. They decided that was the place and the position where they felt all the comfort they needed. Slowly, they got out of the chair and reconnected with the ground and reality. They regained contact with the sensations of their body and reality, i.e., "here and now". When they opened their eyes, they knew that the exercise was over. Mechanism: direct attention away from pain, create a safe place where the body feels comfortable and observe a situation from another perspective. The hypothesis regarding the outcome: decrease in pain.

The hypnosis exercises in the second and fourth sessions were personalized. It involved a sport or a preferred physical activity that the patients did before amputation. Both exercises were different and represented two different activities. The therapist suggested that the patients find a comfortable position on the chair. Then, they had to choose a point, a detail, or an object to focus on and appreciate its characteristics. This focus caused tension in the eyes and eyelids. The therapist then suggested the patients to close their eyes and discover at their own pace all the colors and nuances behind the eyelids. They were then asked to concentrate again on breathing. They were then led to let their memories invade them and to feel again the sensations associated with the emotions linked to the sport. They then perceived all the details of the preparation to be comfortable while engaging in this activity. When ready, they started the sport session while observing the details around them and focusing on the memorized sensations. The therapist led the patients to concentrate on the balance and the muscular tension between their lower and/or upper limbs while making it clear that they were safe. She described all the steps of a session of this sport and, in the end, insisted on the patients' success. The patients were then asked to reunite with their bodies and reality "here and now". The exercise ended when they re-opened their eyes.

Mechanisms: reintegration of positive and comfortable bodily sensations that were experienced before the amputation. The hypothesis regarding the outcome: decrease in pain.

The third exercise was called "Heaven of Peace", in which suggestions of a safe place were delivered. This exercise started in the same way as the previous one. After closing their eyes, the patients were led to discover their "haven of peace". In that haven, they noticed the changes in the environment, including the sounds, the air breathed there, the details of the landscape, the luminosity, and the colors. The therapist suggested the patients spend some time for themselves in that place that is theirs, and appreciate all the sensations brought by the place. She also suggested that they walk and move around in the environment and touch the ground with their feet. She asked them to concentrate on one of the elements that surrounded them and on the effect of time on this element. They then took the time to enjoy the present moment, as a gift that allowed them to feel harmony in this heaven of peace. Enriched by all this, the patients were told that they could use this place every time they needed it. Finally, they got back in touch with reality in the same way as in the previous exercise. Mechanism: direct attention away from pain and create a safe place where the body feels comfortable. The hypothesis regarding the outcomes: decrease in pain, anxiety, and depression.

The fifth exercise "Color-Pain" started with the patients scanning their bodies and focusing on all the sensations. They then identified an area of the body that was uncomfortable, the one with the highest intensity. They marked the area and assigned a color that best corresponded to what they were feeling. They then visualized a large sheet of paper with a diagram of their body on it, and they had to draw the area in question, based on the localization and the color. They returned to a place on their body where the intensity was medium and then another where it was light. They had to repeat the same steps with these two new parts of the body. Then, they were suggested to place the sheet of paper in a small stream and were invited to take the time to appreciate all the details of the place. They searched for a pebble to block the white sheet at the bottom of the stream. They were invited to observe the colors changing due to the flow of water; whose surface remained transparent. As time advanced and the landscapes changed, the patients found a place in their memory where they appreciated the atmosphere, colors, sounds, etc. The colors, atmosphere, sounds, etc. interacted and increased the comfort of the patients, allowing them to feel better. The therapist brought the patients back in touch with reality in the same way as in the other exercises. Mechanism: analgesia. The hypothesis regarding the outcome: decrease in pain.

In case a patient felt discomfort with the personalized exercise, the therapist proposed one of the two following exercises instead of the fourth one (second personalized exercise).

"Travel light" is an exercise based on comfort and goal setting. At the beginning of the exercise, the patients sat comfortably in a chair. They then took the time to observe the sensations, the contacts, the temperature, and the textures of their fingers and hands. The patients identified the different points of support for their bodies on the support in which they were in. They compared the sensations they felt on the right and left sides. Their body, of which each zone was mentioned, was embraced by a feeling of comfort. At one point, a helium balloon appeared. They then attached a string to it and connected it to the first finger of one of their hands. The patients added four more balloons, tied to the other four fingers of the same hand, which raised into the air. A sixth balloon was then suggested below the same hand to enhance the sensation of lightness. A hot air balloon ride allowed them to "travel light". The patients took the time to discover and appreciate all the details of this moment. At a given moment, they took five small white cards and spontaneously

wrote five wishes. They tied each of them to each string of the fingers of the hand and let them all go with the balloons, knowing that they would come true. The balloon landed and the patients returned to reality, enriched by this new skill. The therapist brought the patients back to reality in the same way as in the other exercises. Mechanism: analgesia by inducing lightness sensation in the body. The hypothesis regarding the outcome: decrease in pain and anxiety.

The second exercise was called "Lands of Dreams" and was centered on healing sleep suggestions. The patients started by taking a position that suited them, the one that allowed them to access recuperative sleep. The therapist suggested the patients to notice the occurrences in their bodies and feel all the sensations and changes (from the feet to the head through breathing). The goal was to make the patients feel comfortable. Then, the patients imagined a path, which they decided to take. They were suggested to perceive all the characteristics of it, all the things that they liked were there. The patients saw a portal that led them to the garden of dreams. A staircase of 10 steps led to the portal. The patients decided to go to the dream garden. In the middle of the staircase, they stopped for a few moments to visualize the portal in detail. The gate opened and the garden of dreams appeared. A basket was present and was used to collect the patients' concerns, which they wanted to get rid of. The therapist reminded them that while leaving the garden, they were free to take back the things that were essential to them. The details of the garden could change depending on the perspective of the patients. In this dreamland, everything was done to allow the patients to find all the things they needed. The patients decided to leave the garden when the time came and pass through the gate. When the patients opened their eyes, they knew that their body has had a good night's sleep and that a beautiful day was ahead. Mechanism: direct attention away from concerns and focus on the discovery of an imaginary (dream) world to help improve the quality of sleep. The hypothesis regarding the outcomes: decrease in sleep disturbance, a better quality of sleep, and a decrease in anxiety.

In May 2022, one of the authors (A.B.) called all the participants to review their practice of self-hypnosis.

2.3 Outcomes

- General information: age, sex, date of amputation, type of amputation, pain duration, and type of pain (Table 1).
- The McGill Pain Questionnaire (MPQ) was used to assess the quality of pain (i.e., sensitive and affective). The MPQ is a 58-item questionnaire where words representing the qualities of pain are proposed in 16 categories. Patients have to select one word per category that best represent their present pain on a scale of 0 (not at all) to 4 (extremely). The sensitive subscale is represented by words such as the pain is flickering, pricking, sharp, burning, or freezing. The affective subscale is defined by words such as irritating, exhausting, sickening, or killing. The sensitive subscale has a minimum score of 0 and a maximum score of 36, while the affective subscale has 0 as the minimum score and 28 as the maximum score [32].
- Visual Analogy Scales (VAS) were used to assess the intensity of the pain (when they were in pain) and fatigue (at the moment of filling the questionnaire) intensity, as subjectively perceived by the patients, on a scale of 0 (no pain/fatigue) to 10 (pain/fatigue as intense as you could imagine).

- The Hospital Anxiety and Depression Scale (HADS) was used to examine the levels of anxiety and depression subjectively perceived by the patients over the last week. HADS is a 14-item self-report screening method that contains two subscales containing seven items each for anxiety and depression, with a total score for each ranging from 0 to 21. A higher score indicates greater severity of the symptoms [33].
- The Insomnia Severity Index (ISI) was used to measure insomnia-related difficulties. It comprises seven items that examine the severity of sleep onset, sleep maintenance, satisfaction with current sleep, the interference of the difficulties related to sleep with daily functioning, and the noticeability of impairments due to alterations in sleep. A score between 0–7 corresponds to an absence of insomnia, 8–14 indicates light insomnia, 15–21 indicates medium insomnia and 22–28 indicates high insomnia [34].
- In a follow-up phone call the patients were asked an open question concerning their current practice of hypnosis and the reason why they continued or discontinued practicing it.

Table 1 The sociodemographic variables of the seven cases.

Patients	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Age (years)	61	64	62	58	34	37	61
Sex	Male	Male	Male	Male	Male	Female	Female
Time since amputation (years)	33	21	5	34	2	24	49
Amputation localisation	R thigh	L tibia	R calf	L arm, L leg	L tibia	R thigh	L thigh
Pain duration (years)	32	20	5	34	2	24	33
Pain type	Electric shocks	Burns, tingling, cramps	Twisting	Electric shocks	Tingling, toes crossing	Cramps	Electric shocks

R: right, L: left.

3. Cases

In this section, we described each case and the changes over time. The raw scores before and after the self-hypnosis learning phase for each patient are presented in Table 2.

Table 2 Raw scores of the variables measured before (T1) and after (T2) receiving self-hypnosis training.

Patients	**1**			**2**			**3**			**4**			**5**			**6**			**7**		
Questionnaires																					
Raw total scores	**T1**	**T2**	**Δ**	**T1**	**T2**	**Δ**	**T1**	**T2**	**Δ**	**T1**	**T2**	**Δ**	**T1**	**T2**	**Δ**	**T1**	**T2**	**Δ**	**T1**	**T2**	**Δ**
Mc Gill Pain Questionnaire																					
Sensitive (0–36)	36	23	13	25	23	2	20	27	-7	15	16	-1	26	19	7	30	23	7	21	20	1
Affective (0–28)	18	15	3	11	13	-2	17	16	1	9	9	0	21	24	-3	24	16	8	20	14	6
Pain Intensity (0–10 VAS)	8.9	0	8.9	7.5	3.1	4.4	8.2	0	8.2	8.9	0.5	8.4	8.4	6.5	1.9	10	7.6	2.4	6.5	2.9	3.6
Fatigue Intensity (0–10 VAS)	3.2	5	-1.8	2.9	6	-3.1	2	5	-3	7.2	2.1	5.1	10	5	5	3.4	8.5	-5.1	5.4	1	4.4
Hospital Anxiety and Depression Scale (0–21)																					
Anxiety	7	6	1	9	5	4	5	4	1	4	3	1	15	17	-2	14	9	5	9	6	3
Depression	0	3	-3	3	3	0	7	5	2	1	1	0	6	6	0	4	5	-1	2	4	-2
Insomnia Severity Index (0–28)	9	9	0	9	5	4	8	0	8	19	11	8	17	17	0	15	4	11	7	5	2

VAS = Visual Analogy Scale; Δ = score at T1 minus score at T2.

3.1 Case 1

The patient was a 61-year-old man who underwent a right thigh amputation following extensive burns in 1983. The PLP started one year after the amputation, indicating that at the time of the study, he had been suffering for 32 years. He could perceive his right foot and felt pain (like electric shocks) throughout the leg. The electric shocks lasted 24 to 36 h and occurred once every 2–3 months. The patient did not take any medication or seek psychological therapy concerning his PLP. Before learning self-hypnosis, the patient scored high on the MPQ sensitive and affective subscales and demonstrated high anxiety and pain intensity. The personalized exercises were about him playing tennis. As he did not enjoy the exercise, the "color-pain" exercise was proposed instead of playing tennis.

After receiving self-hypnosis training, the greatest improvements were noticed in pain intensity (Figure 1 and Table 2). The patient also had lower scores on the two subscales of the MPQ followed by a reduction in anxiety. An increase in the intensity of fatigue and depression levels was also reported. The severity of insomnia did not change. From a more qualitative perspective, the patient was satisfied with the different hypnosis exercises; he felt relaxed and at mental ease. The patient reported that self-hypnosis helped him cope with sleep disturbances. He enjoyed the exercises "pain-color" and "soothing white cloud". After the study, he reported that he tried to perform the exercises when he was in pain. However, the pain was so intense that he could not enter the hypnotic state. Six years later, he still performed those two exercises sometimes before going to bed or when he had trouble falling asleep.

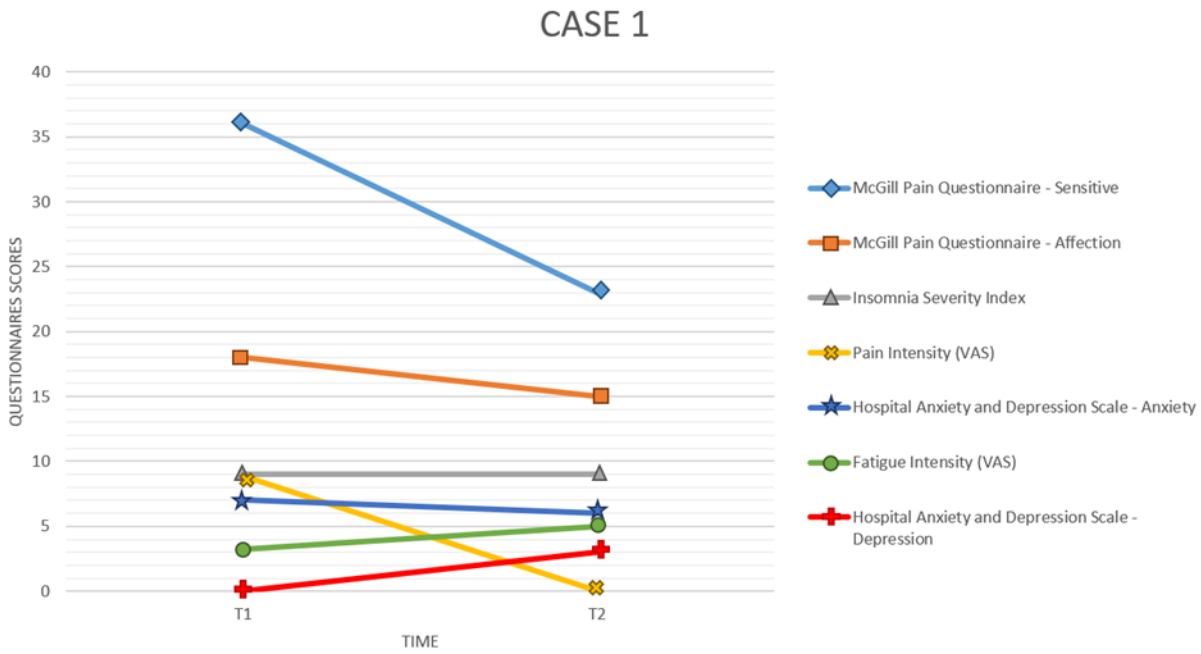

Figure 1 Questionnaire score evolution of case 1. T1 = before self-hypnosis training, T2 = after self-hypnosis training, and VAS = Visual Analogy Scale.

3.2 Case 2

The patient was a 64-year-old man who, in 1995, had an ulcer in the left tibia because of arterial obstruction, which evolved into necrosis and had to be amputated. The PLP appeared one year after

amputation, implying that the patient had been in pain for 20 years. The patient experienced burning and tingling sensations and also felt cramps in his (absent) calf. Those painful sensations occurred in the evenings, four times per week, depending on the activity of the day. At the time of the study, the patient was taking an anti-epileptic drug but infrequently. He did not receive nor seek any kind of therapy, although he agreed to participate in the study. Before self-hypnosis training, the patient had high scores in the sensitive subscale of the MPQ, anxiety, pain intensity and experienced light insomnia. His personalized exercises were a football game and a walk in nature.

The patient showed improvements in the severity of insomnia, pain intensity, and anxiety (Figure 2 and Table 2). The sensitive subscale score of the MPQ decreased while the affective score increased after learning self-hypnosis. The intensity of fatigue increased, whereas depression remained unchanged throughout the study. Qualitatively, the patient enjoyed most of the personalized exercises. He reported that after the hypnosis exercises, he did not feel any PLP. He also felt that his mood improved and as if he had "a more rested head". Six years after the study, he did not practice self-hypnosis anymore because he failed to find the time. The patient reported that he would like to try again as it was beneficial.

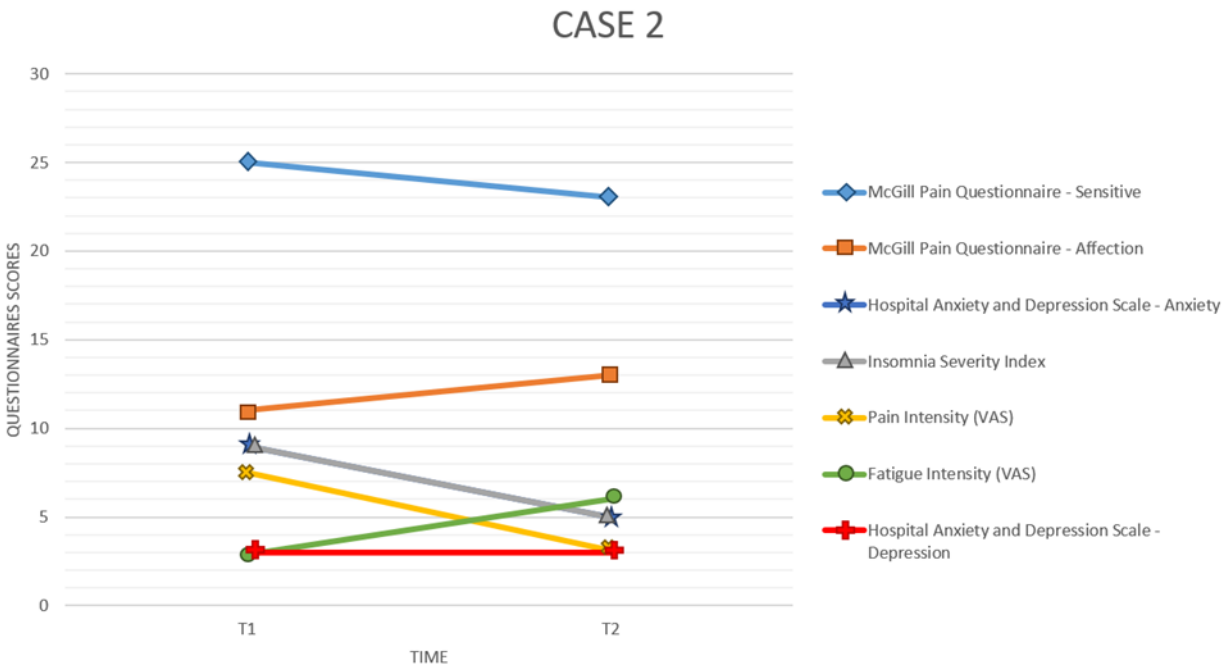

Figure 2 Questionnaire score evolution of case 2. T1 = before self-hypnosis training, T2 = after self-hypnosis training, and VAS = Visual Analogy Scale.

3.3 Case 3

The patient was a 62-year-old man admitted to the emergency room with an ulcerated wound on the right heel of a diabetic foot in 2011. He underwent amputation below the right knee because the infection had spread to the calf. The PLP started immediately after the surgery, with five years of pain before he participated in the study. The patient described the pain as if someone turned his leg in the opposite direction. This pain mostly occurred when he remained standing for a long time or while gardening. At the time of the study and during the follow-up, he took anti-epileptic drugs. He had also tried (not at the time of the study) other techniques, such as acupuncture and

auriculotherapy, which is a kind of acupuncture but only applied to the ear. Before starting self-hypnosis training, the patient experienced light insomnia and high levels of anxiety and pain. His personalized exercises were a walk in nature and a ride on a bike.

After self-hypnosis training, the patient reported a decrease in the severity of insomnia and pain intensity. The patient also reported improvements in depression, anxiety, and the affective subscale score of the MPQ. An increase in the intensity of fatigue and the sensitive subscale score of the MPQ was also observed (Figure 3 and Table 2). The patient also reported that he appreciated getting self-hypnosis training. Specifically, he liked the relaxing and appeasement effects of hypnosis. He felt more relaxed mentally and physically during the study period when he practiced self-hypnosis. Self-hypnosis strongly affected and improved his sleep-related difficulties. During the follow-up, the patient reported that he did not practice self-hypnosis anymore, although it was beneficial. He stopped practicing because he failed to find the time.

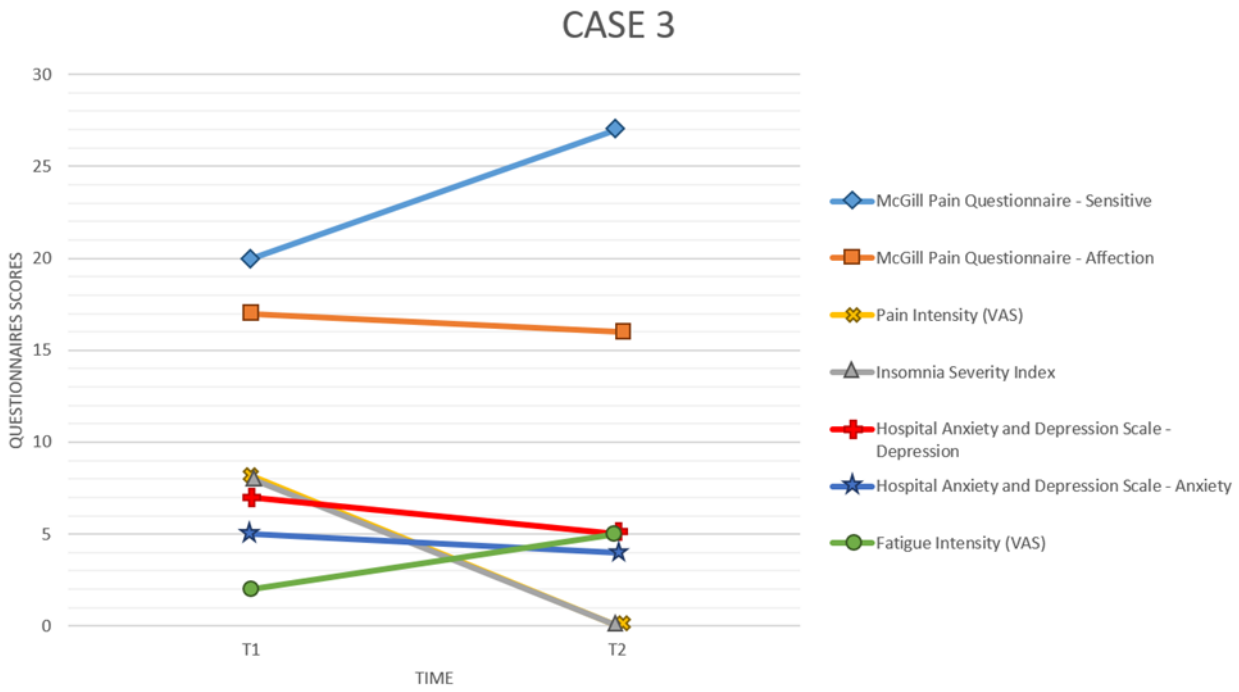

Figure 3 Questionnaire score evolution of case 3. T1 = before self-hypnosis training, T2 = after self-hypnosis training, and VAS = Visual Analogy Scale.

3.4 Case 4

The patient was a 58-year-old man who had his left arm and leg amputated after a car accident in 1982. The PLP appeared in the same year (34 years of pain). At the time of the study, he felt pain only in his leg. He described the pain as electric shocks and prickles as if he was alternately "putting 80 or 100 volts" on his missing foot. He never underwent psychotherapy but tried anti-epileptic drugs, which he stopped because of a feeling of numbness after taking them. During the follow-up, he sometimes took light painkillers. At baseline, the patient had moderate insomnia and high intensity of pain. His personalized exercises were to swim and ski.

The severity of insomnia and the intensity of pain decreased considerably after self-hypnosis training (Figure 4 and Table 2). The intensity of fatigue and anxiety decreased after training, while the sensitive subscale score of the MPQ worsened slightly. Depression and the affective subscale

score of the MPQ remained unchanged throughout the study but were quite low at baseline. Qualitatively, the patient liked the mental and physical relaxation he felt during hypnosis. He reported that hypnosis helped to decrease the severity of insomnia. Although he did not practice hypnosis anymore during the follow-up, he used the same breathing exercises as those that were performed for inducing hypnosis (that were given by AV at the time of the study) when he felt the need to slow down or at the onset of pain.

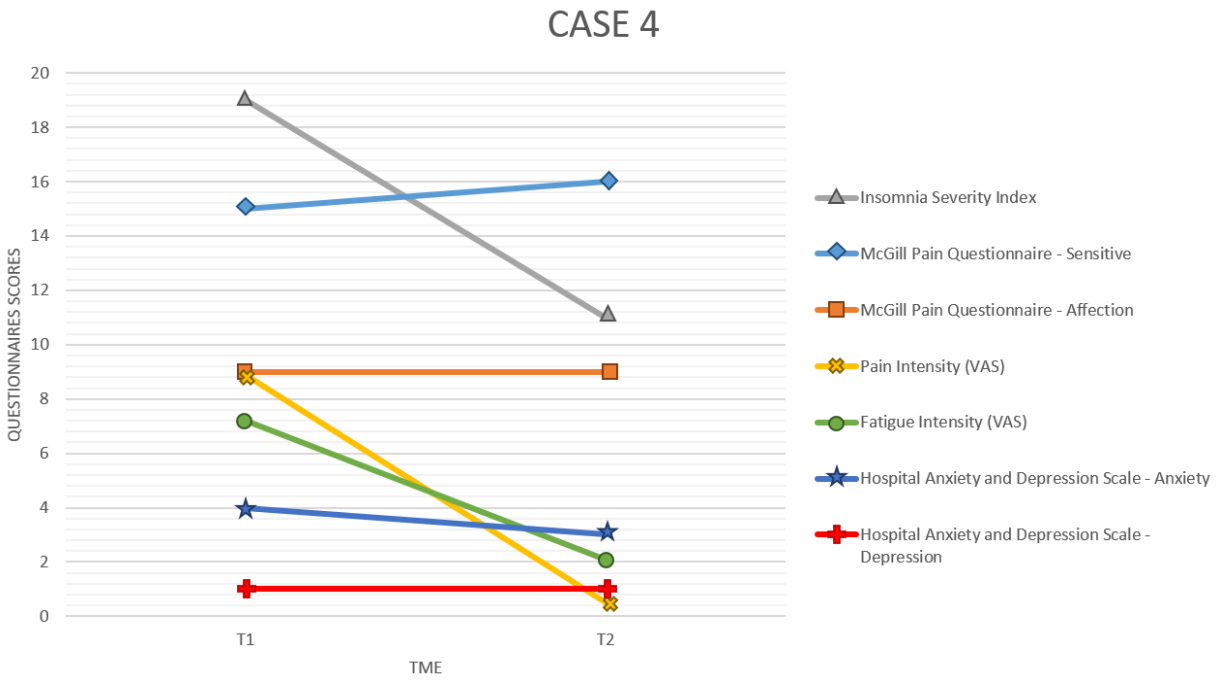

Figure 4 Questionnaire score evolution of case 4. T1 = before self-hypnosis training, T2 = after self-hypnosis training, and VAS = Visual Analogy Scale.

3.5 Case 5

The patient was a 34-year-old man admitted to the emergency room after a traumatic car accident in 2014. He was a pedestrian, and the injuries to his left tibia were so severe that it had to be amputated. The PLS appeared at the time of the amputation, indicating that he had been suffering for two years. The patient described the sensations as tingling in the evening, several times a week. He also felt that his calf was present and his toes were crossing. During rehabilitation, the medical staff gave him some anxiolytics a few times, and he had psychological support. He tried to undergo therapy but stopped because he did not feel like reliving the incident. He did not take any medication either earlier or during the follow-up. Before starting the self-hypnosis training, the patient suffered from moderate insomnia and high fatigue intensity. He also had high pain-sensitive scores of the MPQ and pain intensity. His personalized exercises were a football game and swimming.

After receiving self-hypnosis training, the patient showed a reduction in the intensity of fatigue and the sensitive subscale score of the MPQ. The intensity of pain also decreased, whereas depression and the severity of insomnia remained unchanged. Anxiety and the affective subscale score of the MPQ increased after self-hypnosis training (Figure 5 and Table 2). He reported that he enjoyed the football exercise and that, in general, during the study, he felt more at ease mentally,

had a better mood, and slept better. He did not practice self-hypnosis after the study because he did not find the time.

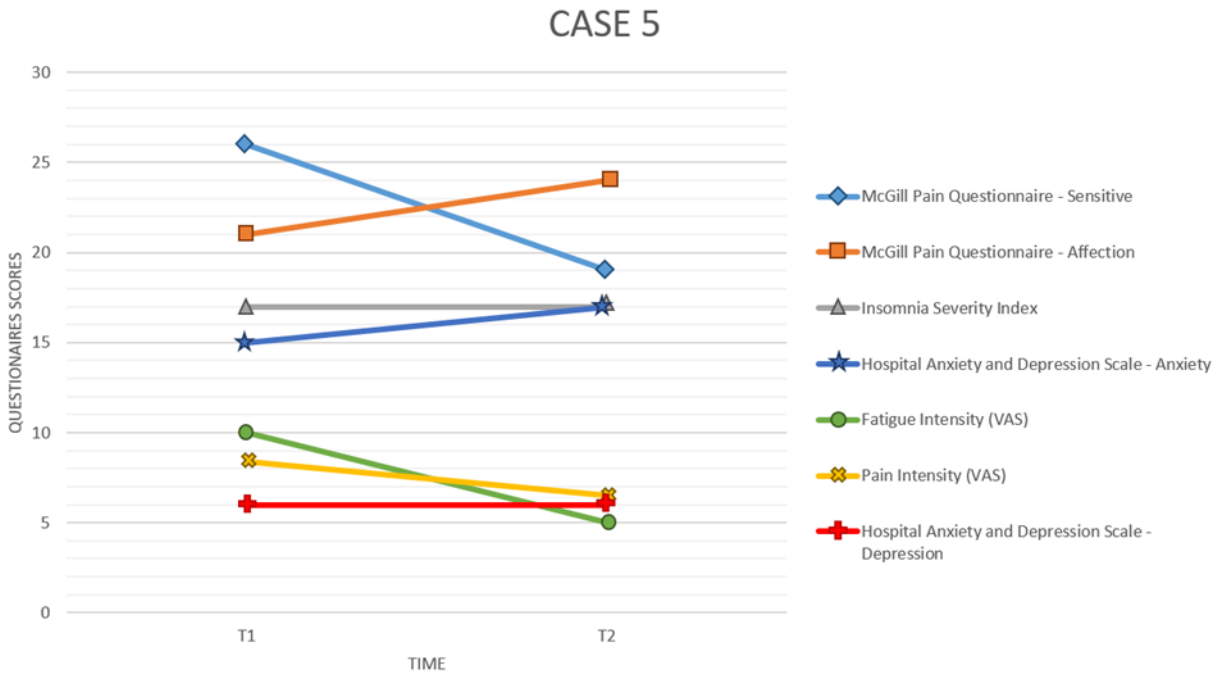

Figure 5 Questionnaire score evolution of case 5. T1 = before self-hypnosis training, T2 = after self-hypnosis training, and VAS = Visual Analogy Scale.

3.6 Case 6

The patient was a 37-year-old woman whose right thigh was amputated in 1992 following a traffic accident. The PLP appeared at the time of the amputation, implying that she had been in pain for 24 years. She reported that the PLP was her "disease" barometer. Each time the pain appeared, usually at night, it "signaled" that an infection was present and that she would be sick for the next few days. When the study was conducted, the patient sometimes felt as if her leg was being pulled off and felt cramps in her foot about once a month. She never underwent psychotherapy but took antidepressants a few years after the amputation. At baseline, the patient had high pain intensity, anxiety, pain-sensitive subscale score of the MPQ, and moderate insomnia. Her personalized exercises were to ride a bike and run outside.

The severity of insomnia and both subscale scores of the MPQ improved considerably after self-hypnosis training. She also experienced lesser anxiety and intensity of pain. A slight increase in fatigue and depression was also found after self-hypnosis (Figure 6 and Table 2). The patient enjoyed the "soothing white cloud" exercise, which she performed regularly at the time of the study. She felt a difference in the experiences of pain, mood, and fatigue. Hypnosis eased her mentally and physically. She also used the CD when she had a headache, not only for PLP. In general, she felt calm. She reported that hypnosis helped her in self-management as she was able to step back, sit down, and think about a situation that could be problematic. Before self-hypnosis training, she reported being quite impulsive.

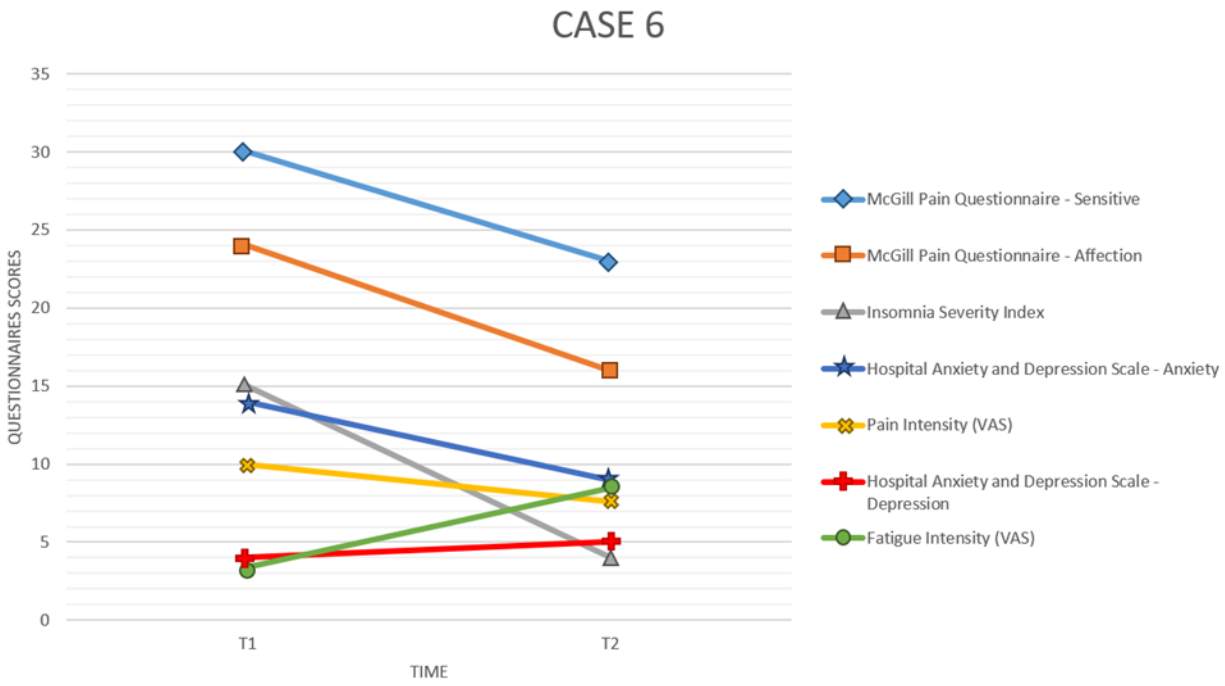

Figure 6 Questionnaire score evolution of case 6. T1 = before self-hypnosis training, T2 = after self-hypnosis training, and VAS = Visual Analogy Scale.

3.7 Case 7

The patient was a 61-year-old woman whose left thigh was amputated at the age of 11, following a traffic accident during which she was biking in 1967. She experienced neuropathic pain in the stump, which appeared in 1983 (33 years ago). When the study was conducted, she reported feeling electric shocks that lasted three days. She tried many types of therapy, such as anxiolytics, kinesiology, and neuro-linguistic programming, to relieve the pain, but none of them worked. Before starting self-hypnosis training, the patient had high scores in both subscales of the MPQ, as well as, high pain intensity. She was suffering from light insomnia. Her personalized exercises were to ride a bike and swim.

After learning self-hypnosis, the affective subscale score of the MPQ showed the greatest improvement (Figure 7 and Table 2). The patient also had lower scores of anxiety, pain, and the intensity of fatigue, and also lower sensitive subscale scores of the MPQ. The severity of insomnia also decreased. The level of depression increased. After receiving self-hypnosis training, she enjoyed the personalized (biking) exercise because she could redo the actions, which allowed her to re-appropriate the movements of the bike. This stimulated positive feelings. The exercise also allowed her to re-experience the trauma differently and accept it. She also mentioned that the pain-free gaps were longer and less painful. However, she discontinued practicing self-hypnosis because she failed to find the time.

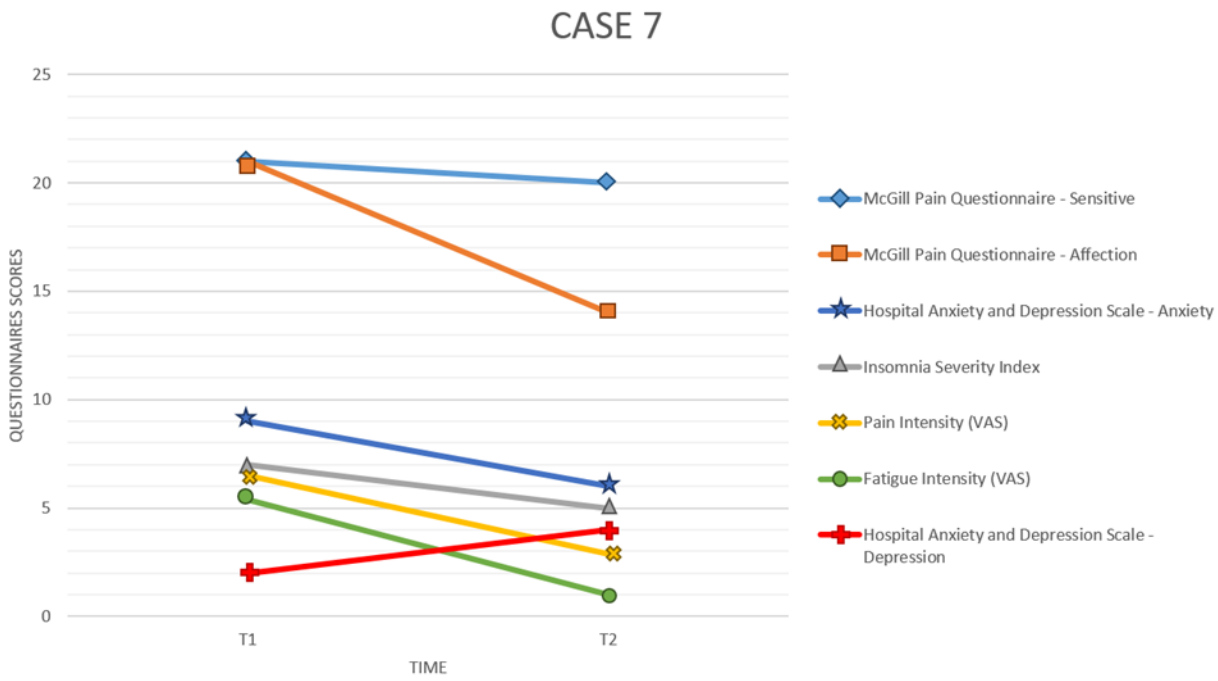

Figure 7 Questionnaire score evolution of case 7. T1 = before self-hypnosis training, T2 = after self-hypnosis training, and VAS = Visual Analogy Scale.

4. Discussion

PLP occurs in more than half of the cases of amputation and often evolves into chronic pain, causing the individual a high level of physical and psychological discomfort [3]. Complementary approaches, such as hypnosis, are effective in reducing pain, emotional distress, and fatigue in patients suffering from chronic pain [24, 25, 28, 29]. Thus, in this study, we assessed whether self-hypnosis training would decrease pain perception (i.e., sensitive and affective aspects) and intensity, sleep problems (i.e., insomnia), and emotional distress (i.e., anxiety and depression) in seven people suffering from PLP.

Our results indicated that the quality of pain changed in six patients. These patients had lower scores in the sensitivity and affective subscales of the MPQ, which indicated that they felt lesser pain and discomfort in the phantom limb, and their experience was associated lesser with negative descriptions. No study, which investigated the effect of hypnosis on PLP, used the MPQ to assess the quality of pain. However, studies on hypnosis in other chronic neuropathic pain populations showed that self-hypnosis training and hypnosis sessions with a therapist decreased sensitive and affective scores of the MPQ [35-37].

All patients had lower pain intensity, which was similar to the results of other studies investigating self-hypnosis in PLP [17, 38]. The level of anxiety decreased in the seven patients, whereas the reduction in the depression levels was less prominent. However, depression levels increased in two patients. While the reason for the increase in the depression level in case 1 is not known, case 7 suffered burnout at the time of the study. This confounding factor might have affected the depression score. The HADS [33] asked how the person felt for the last seven days; thus, it is quite sensitive to a depressive feeling in the moment than to a longer term depression. To our knowledge none of the previous studies that assessed hypnosis in PLP evaluated anxiety and depression as we did, thus, preventing us from making any comparisons. However, studies that

investigated the efficacy of hypnosis in other types of chronic pain populations showed the same results, i.e., a reduction in anxiety and depression after undergoing self-hypnosis training [24, 25, 28, 29]. While the severity of insomnia decreased in four patients, the intensity of fatigue increased in more than half of the patients. The reason for this discrepancy might be that the ISI scale assesses sleeping difficulties over the last week, representing the mean sleep disturbance. The item related to the intensity of fatigue asked about the level of fatigue at that moment. It might be possible that the patients felt a greater degree of fatigue by chance when they met the therapist for the second time.

Most studies (n = 10) that assessed the potential of hypnosis for alleviating PLP were case studies based on one patient. Only one study was a non-randomized controlled trial (Table 3). In 2002, Oakley et al. proposed a review of the literature, and in 2012, Moura et al. completed it. Here, we updated the review on the role of hypnosis in the reduction of PLP.

Table 3 The Role of Hypnosis in Phantom Limb Pain or Phantom Limb Sensation.

Authors and year	Design	Number of patients	Intervention	Diagnosis	Results
Siegel, 1979 [39]	Case study	1	Ten sessions of therapy were conducted, seven of which were dedicated to hypnosis. Only one exercise was proposed: Glove anesthesia. The hypnotic induction started with eye fixation, then glove anesthesia was performed by asking the patient to imagine herself in a mountain cabin with numbness and chills. Initially, the exercise was not directly applied to the phantom limb, it was done after. A follow-up session was conducted after one month. There was no mention of an audio recording given to the patient.	The left limb above the knee was amputated due to a history of circulatory diseases.	A good response to hypnosis was found. A reduction in PLP, mood-related issues, and medication after therapy and at the follow-up after one month was observed. Self-hypnosis was practiced.
Chaves, 1986 [40]	Case study	1	Three sessions of hypnosis were conducted with relaxation and tension reduction suggestions. Self-hypnosis was performed. Follow-up over five years.	The arm was amputated (the side was not mentioned). The PLP was described as a feeling of tension and as if the hand and the arm were in an uncomfortable position.	Self-hypnosis was performed with an audiotape recording once a month. A reduction in PLP was recorded.

Chaves, 1993 [41]	Case study	1	Hypnosis with suggestions of relaxation and phantom limb reduction. The patient used images of decapitated ants and cut bands. Self-hypnosis was practiced with an audiotape. The number or length of the hypnotherapy sessions was not mentioned.	The right leg (mid-thigh) was amputated. The patient described the PLP as biting ants, tight bands, and muscle tension.	A 30% reduction in the discomfort and frequency of pain was reported. Phantom limb pain decreased.
Brown et al., 1996 [42]	Case study	1	Hypnosis with analgesia suggestion in the phantom limb and reduction in the phantom limb length. There was no mention of an audiotape given to the patient.	Amputation of the right knee and leg associated with cancer. The patient had PLP and nausea.	No mention of a change in pain. At the one-year follow-up, the patient could wear his prosthesis and hike.
Muraoka et al., 1996 [43]	Case study	1	Hypnosis was performed for 30 min once a week for three years. Hypnosis consisted of relaxation and movement of the missing limb. There was no mention of an audiotape given to the patient.	Amputation was performed without anesthesia. PLP appeared immediately after the incident and was described as burning and stinging.	A reduction in the intensity and frequency of PLP throughout the therapy was reported. Addiction to painkillers disappeared.
LeBaron & Zeltze, 1996 [44]	Case study	1	Hypnosis with suggestions of muscle relaxation and contraction in both legs. There was no mention of an audiotape given to the patient or the number of sessions.	The left leg was amputated. The patient described the PLP as cracking in the toes, stabbing in the foot, and jerking in the leg.	Pain reduction (50 to 100%) at the follow-up after two weeks by practicing self-hypnosis or listening to an audiotape, along with improved sleep and reduction in PLP, were reported.

Ersland et al., 1996 [45]	Case study	1	Hypnosis with suggestions of relaxation, looseness, and movement in the arm and fingers (no mention of the number of sessions). Self-hypnosis was practiced. There was no mention of an audiotape given to the patient.	The right arm above the elbow was amputated because of a train accident. The PLP in the wrist and fingers was described as cramps and as if they were placed in a strange position.	A reduction in PLP was reported.
Rosen et al., 2001 [46]	Case study	2	A combination of CBT and hypnosis was proposed. The therapy lasted three years and consisted of the same procedure for both patients. The CBT consisted of the acceptance of the loss, reaction to the traumatic experience, handling of negative thoughts, and teaching about physiological and psychological aspects of PLP. "Save place" (Norwegian forests for both patients), relaxation, and comfortable limb movement and position were practiced as hypnosis exercises. Self-hypnosis practice was encouraged. There was no mention of an audiotape given to the patient.	Patient 1: the right arm was ripped off during a train accident. He was conscious at that moment. PLP was described as cramps, warm radiations in the arm, and contraction. Patient 2: the loss of three fingers in an accident at work. The patient had severe pain in hand, which he described as cutting. He also experienced intense pain when the hand was moved uncomfortably, during a change in weather, and under stress.	Patient 1 showed a good response to CBT. PLP was absent during the hypnosis exercise but returned after hypnosis. The patient practiced self-hypnosis but preferred hetero-hypnosis. The pain was less intense and less frequent after hypnotherapy. Patient 2 took more time to accept the loss via CBT. Reduction in pain and pain frequency was reported. No mention of him practicing self-hypnosis.
Bamford, 2006 [47]	Non-randomized	25	A combination of psychotherapy, visualization, movement of the imaginary limb, hypnotic analgesia,	There were 18 patients with lower limb amputation and seven patients with upper limb amputation. PLP was present,	Reduction in pain after six weeks and at the follow-up after six months was reported.

			and self-hypnosis. All patients received the same procedure; six sessions in total, one session per week + self-hypnosis daily at home. There was no mention of an audiotape given to the patients.	but a detailed description of it was not provided.	Greater mobility of the phantom limb after each session was found. The mobility of the phantom limb was greater immediately after each session.
Oakley et al., 2002a, b [38, 48]	**Case study**	**2**	**Patient 1: "special place" exercise, with suggestion of positive change . She was encouraged to modify her pain representation to reduce it. Eight sessions of 25 min each were performed every week. There was no mention of an audiotape given to the patient.** **Patient 2: suggestion of movement of the missing limb . There was no mention of an audiotape given to the patient.**	**Patient 1: above-knee amputation of the right leg was performed because of peripheral vascular disease. PLP started two years after her amputation and was described as pain caused by pins, needles, and slicing/cutting in the missing foot. She also felt that her toes were in a tight grip and had chiseling pain in her missing ankle.** **Patient 2: the left brachial plexus was amputated. PLP appeared directly after amputation and was described as intense cramp-like pain and electric shock. The first type of pain lasted for 20 min, while the second type was shorter but more frequent.**	**Patient 1: good response to hypnosis. The chiseling pain was absent, but the sensation on the missing toes was present.** **Patient 2: reduction in pain intensity was reported.**

Chan, 2006 [49]	**Case study**	**1**	**Hypnosis with analgesia suggestions. Self-hypnosis practice was encouraged, and 20 sessions were performed. There was no mention of an audiotape given to the patient.**	**Left leg amputation was performed with neuropathic PLP. The patient described the pain as pins, needles, cutting, and drill jabbing the missing leg.**	**A reduction in pain severity and affective pain and an increase in self-confidence and control over pain was reported.**

PLP = Phantom Limb Pain; CBT = Cognitive Behavioral Therapy. The studies we added are in bold.

Hypnosis is effective in alleviating the intensity, severity, and frequency of PLP (Table 3). This complementary approach also improves sleep difficulties, the ability to return to work, and the overall quality of life. An interesting factor that is worth highlighting is that most studies indicated that patients practiced self-hypnosis and found it helpful, but there was no mention of an audiotape being given to them. In our study, we provided a CD with the exercise performed during the session, and patients were encouraged to listen to it daily until the next session. However, we could not systematically control if patients played the CDs daily, as recommended. At the follow-up after six years, only three patients still practiced hypnosis to improve their sleep. The other patients did not practice hypnosis or played the CDs because they failed to find the time. However, they emphasized that they found it useful during the study, and practicing hypnosis helped them. Future studies should address this factor to identify ways to implement self-hypnosis in daily life. There are several ways to ensure this, such as maintaining a diary, receiving phone calls from researchers, or using mobile applications. The first solution was implemented in a study by Horton-Hausknecht et al. [50]. The authors asked the patients to note the frequency with which they listened to recordings related to hypnosis or meditation. Of the 46 patients (26 in hypnosis and 20 in meditation), only nine patients provided this information. In another study [51], 6 of the 11 patients who received a hypnosis recording listened to it (no information on frequency was provided). Thus, asking patients to monitor their practice seems unreliable [52]. Although telephone calls might be considered, they are time-consuming. Collaboration and balancing between the availability of patients and researchers could compromise the implementation of this approach. One inexpensive and innovative strategy to monitor self-hypnosis practice is the use of mobile applications. However, no study has tested the usefulness of applications for the recall of hypnotic exercises. The use of applications to manage chronic pain is relatively recent and monitors changes in the intensity of pain through treatment [53].

In an attempt to explain the mechanism of action of hypnosis in PLP, within the framework of this study, we considered PLP as a type of chronic pain. As the pain becomes chronic, pain representations go from sensory/nociceptive perception to affective cognition and motivation. In chronic pain, hypnosis, seems to act mostly on the corticolimbic system and, to a lesser extent, on the sensory aspects of pain [26]. Nusbaum et al. [54] demonstrated the action of hypnosis on chronic pain. In the study, 14 patients with chronic low back pain were divided into two groups; the first group received suggestions for analgesia, while the second group received suggestions focused on well-being without any mention of pain. The suggestions were given in an ordinary state of consciousness and a hypnotic state, and the intensity of pain was assessed after each condition. During hypnosis, both types of suggestions significantly decreased pain intensity, while only analgesic suggestions decreased pain intensity during the ordinary state of consciousness. This indicated that during hypnosis, the suggestions that target the sensory-discriminative pain experience and the motivational-affective pain experience both influence pain perception. These results were similar to those of previous studies, thus highlighting the fact that hypnotic suggestions act in a dynamic and multidirectional manner rather than in a linear and unidirectional manner [55, 56]. We provided various suggestions targeting pain and chronic pain comorbidities, such as sleep and comfort, which further highlighted the multidimensional action of hypnosis. Another possible mechanism that might be relevant and worth investigating is the sense of agency, which might be defined as the “feeling of controlling one’s own action and, through them, events in life” [57]. While a recent study found that decreasing agency through hypnosis also decreased pain perception in

women with fibromyalgia [58], we believe that in PLP, an increase in the agency might help patients to gain better control over the phantom limb and its mobilization. Although we suggested the movement of the phantom limb in each exercise, we did not evaluate the agency that prevented us from going further in the development of this hypothesis. However, future studies might consider this component as a possible mechanism.

Furthermore, one can argue that the level of hypnotizability moderates the effects of hypnotic analgesia [59, 60]; however, we did not evaluate it. Although higher hypnotic suggestibility is associated with greater pain relief, people with medium suggestibility also manage pain better through hypnosis (for a review, see [27]). For the 20–30% of the population with low hypnotizability, there are no results based on which a strategy might be adopted. In our clinical experience, we never test hypnotizability before practicing hypnosis with patients (e.g., during surgery, chronic pain, oncology) assuming that all patients (with high, medium, and low hypnotizability) benefit from hypnosis.

Most studies performed were case studies, and thus, the results we obtained should be generalized with caution. More studies with mixed designs (i.e., qualitative and quantitative) should be conducted in the future. In this study, 100 patients who matched the inclusion criteria were contacted for participation. Only seven patients agreed to participate in the study. This might highlight the difficulties in conducting studies with rigorous protocols that require many participants.

Nowadays, the interest of new technologies, such as virtual reality (VR), has increased among clinicians and researchers, probably for their effects on experimental, procedural, and chronic pain [61]. A recent review (k = 8, N = 47) showed an improvement in PLP after using VR (between 1 and 20 sessions of VR lasting for 5–90 min, depending on the study). However, the authors also found that most studies included in their review were case studies, which limited the generalization of the results [62]. VR has been combined with hypnosis to form a technique called Virtual Reality Hypnosis (VRH) [63]. It is defined as "a hypnotic induction and analgesic suggestion delivered by a customized virtual reality (VR) hardware/software" [64]. Since VR and hypnosis seem to be effective in alleviating pain in the phantom limb, the combination of these two techniques might be suggested to some patients.

This study has some limitations. First, the results presented here cannot be generalized as it is a multiple-case study. Second, no control group or control condition was present; thus, the real effect of the treatment administered is not known (hypnosis or therapeutic presence). Future studies should include more participants and use a mixed design approach allowing for the combination of a quantitative and qualitative understanding of hypnosis in PLP. Longitudinal studies need to be performed for a better understanding of how self-hypnosis can benefit patients in the long term.

5. Conclusions

To summarize, in this study, we discussed the benefits of practicing self-hypnosis to reduce phantom limb pain. This approach allowed the patients to play an active role in their health and improve their quality of life by decreasing pain intensity, modifying the qualities of pain (i.e., sensitive and affective components), anxiety, and the severity of insomnia. Future studies need to be conducted with larger samples and more rigorous methodologies.

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Author Contributions

Aminata Bicego: Data acquisition, writing paper, reviewing paper. Pauline Delmal: Data acquisition, analysis of the data, reviewing paper. Didier Ledoux: analysis of the data, reviewing paper. Héléna Cassol: reviewing paper. Benoît Maertens de Noordhout: reviewing paper. Alfredo Cerasoli: reviewing paper. Olivia Gosseries: reviewing paper. Marie-Elisabeth Faymonville: study design, reviewing paper. Audrey Vanhaudenhuyse: study design, data acquisition, analysis of the data, writing paper, reviewing paper.

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Competing Interests

The authors declared that no competing interests exist.

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