

Phantom phenomena in limb amputees – a review article

Wrażenia fantomowe u chorych po amputacji kończyn – artykuł poglądowy

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Abstract

Amputation leading to the loss of a body part is associated not only with significant economic costs, but also serious consequences of medical and socio-psychological nature. It is the ultimate means to save a life or improve its quality. The most difficult challenges faced by amputees include accepting changes regarding their own physiognomy and the resulting life restrictions. The patient subjected to amputation is faced with an extremely difficult adaptation process, during which s/he should strive for a maximum degree of independence. Unfortunately, a large group of patients also struggles with various types of sensations and pain located within the lost limb – i.e., so-called phantom phenomena. This is a special group of phenomena of diverse nature, “located” within the lost limb.

The occurrence of phantom limb syndrome in amputee patients is extremely common. This problem affects from 45% to even 98% of patients after amputation of one or both upper and lower limbs. The main purpose of this article is to describe phantom phenomena observed in patients after limb amputation in light of current literature. The definition, historical outline, types of phantom phenomena are presented, as well as hypothetical pathomechanisms, factors influencing the frequency and intensity of phantom phenomena and available treatment methods. The work was based on numerous text sources and the author's own experience.

Słowa kluczowe

amputacja kończyny, etiologia amputacji, wrażenia fantomowe, ból fantomowy, leczenie bólu fantomowego

Streszczenie

Amputacja prowadząca do utraty części ciała wiąże się nie tylko ze znacznymi kosztami ekonomicznymi, ale i poważnymi konsekwencjami natury medycznej i społeczno-psychologicznej. Jest ostatecznym środkiem mającym na celu ochronę życia lub poprawę jego jakości. Do najtrudniejszych wyzwań, z jakimi przychodzi mierzyć się osobom po amputacji należy zaakceptowanie zmian we własnej fizjonomii oraz wynikające z nich, ograniczenia życiowe. Pacjent po amputacji ma przed sobą niezwykle trudny okres adaptacyjny, w trakcie którego powinien dążyć do maksymalnego stopnia samodzielności. Niestety duża ich grupa zmagą się także z różnego rodzaju doznaniem i dolegliwościami bólowymi umiejscowionymi w obrębie utraconej kończyny – tak zwanymi wrażeniami fantomowymi. Jest to szczególna grupa odczuć o zróżnicowanym charakterze „umiejscowionych” w obrębie utraconej kończyny. Występowanie zespołu kończyny fantomowej u pacjentów po amputacjach jest niezwykle częste. Problem ten dotyka od 45% do nawet 98% z nich po amputacji jednej lub obu kończyn górnych i dol-

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nych. Głównym celem artykułu było opisanie wrażeń fantomowych, obserwowanych u chorych po amputacji kończyn w świetle aktualnej literatury. Przedstawiono definicję wrażeń fantomowych i ich rodzaje, rys historyczny, hipotetyczne patomechanizmy, czynniki wpływające na częstość i intensywność wrażeń fantomowych oraz dostępne sposoby leczenia. Praca powstała w oparciu o liczne źródła tekstowe i doświadczenia własne.

INTRODUCTION

Amputation is the loss of a part of the body that can occur as a result of a mechanical injury or a planned surgical procedure. Considered within the second context, it has an extremely long history and is one of the oldest medical procedures¹. Amputation is the ultimate means to save a life or improve its quality. It is associated not only with significant economic costs, but also serious consequences of medical and socio-psychological nature², especially in countries where prosthetics are not available, mainly due to financial reasons³.

One of the most difficult challenges faced by people after amputation, include accepting changes in one's own physiognomy and the living restrictions resulting from them. What is more, the majority of patients after amputation of a body part struggle with so-called phantom phenomena^{4,5}. This is a specific group of sensations, diverse in nature, "located" within the area of the lost limb⁶. Despite constant interest in this issue, the discovery and description of complicated pathophysiological mechanisms remains valid⁷⁻¹⁰.

This work was created on the basis of numerous text sources, mainly Polish- and English-language articles from medical journals and the authors' own experiences.

LIMB AMPUTATION PROCEDURE – DEFINITION, EPIDEMIOLOGY AND HISTORICAL OUTLINE

"Amputation is a medical procedure that involves the partial or complete removal of a limb"¹¹. From an operational point of view, this procedure involves surgical exposure of the bone in order to sever it or exarticulation of the joint. In addition, during surgery, it is necessary to properly

prepare the soft tissues so that it is possible to form a proper stump¹². The amputation procedure may be a planned and necessary procedure to save a patient's life, but amputation may also be the consequence of an accident, during which the patient suddenly, or later due to treatment complications, loses a part of his/her body¹³⁻¹⁶.

Brief historical outline

The term "amputation" derives from Latin, and specifically, from the adjective *ambi* – "circularly" and the verb *puto, putare* – meaning "cut". The term was most probably first used in a medical context by Lowe in the work entitled *A discourse of the whole art of chirurgery*¹⁷. There are many indications that amputations should be among the group of oldest surgical procedures. Taking the content of murals from the Paleolithic period into account, it can be estimated that the history of amputation reaches as far back as 36,000 years¹⁹. In the past, amputations were also performed for other than medical reasons, for example as a form of punishment or a type of ritual^{12,17}. According to the rules of Sharia law, theft was punished by amputation of the right hand or its fingers or cross amputation (right hand and the fingers of the left hand), while re-offense (so-called recidivism) resulted in amputation of the foot^{19,20}.

In turn, the Code of Hammurabi included a system of penalties based on the principle "eye for an eye, tooth for a tooth", in other words, with what you perform the offense, you will have cut off²¹. For example, theft, medical blunders or the removal of markings by a slave were punished by cutting off one's hand¹⁹. The execution of the Sandomierz nobleman Michał Piekarski in Warsaw in 1620 for attempting to assassinate

King Zygmunt III Waza, involving, inter alia, cutting off the hand (raised at the king) is also documented²². According to Amnesty International, amputations as a form of punishment are still being performed in many countries^{23,24}.

Despite continuous advancements in medicine, amputation of limbs still currently remains an extremely important clinical issue, which lies in the sphere of interest of surgeons, orthopedists as well as physiotherapists and ortho-prosthetists.

Epidemiology

In Poland, amputations are performed very frequently: almost 400/1 million individuals annually²⁵. In comparison, for Italy, the ratio is 130/1 million, for the United Kingdom almost 120/1 million, for Spain only 50/1 million, and for the rest of the European Union from 100 to 150/1 million individuals²⁵. Poland is the only European Union country in which the number of limb amputation procedures due to atherosclerotic diseases has been increasing dramatically for years. There are many reasons for this, including, among others, lifestyle, level of social awareness, lack of experience of doctors at family medicine clinics, as well as lack of effective systemic solutions and often, economic calculation^{3,25,26}.

Indications for limb amputation surgery

The basic typology of amputation indications takes the degree of risk they pose to the health and/or life of the patient into account. Two basic types can be distinguished:

- absolute indications that we deal with when surgery must be carried out to save a patient's life. Such amputation indications are divid-

Table 1
Types of indications determining the performance of amputative surgery

Type of indication	Absolute indications (posing a direct threat to the patient's life)		Relative indications (not constituting a direct threat to the patient's life)
	primary (requiring immediate surgery)	secondary (the operation may be deferred in time, but must be carried out)	
Examples	<ul style="list-style-type: none">• so-called amputations performed when the victim has already lost his limb during an accidental event²⁸,• extensive crushing of limbs occurring during various accidental events²⁹,• gas gangrene with rapidly progressing course³⁰,• septic shock or fulminant purpura which is a complication of severe sepsis^{31,32},• lack of adequate medical staff/facilities, e.g. during wars or large scale natural disasters³³.	<ul style="list-style-type: none">• malignant tumours, e.g. osteosarcoma³⁴.• serious thermal and radiation burns,• IV degree frostbite,• critical limb ischemia, including diabetic foot³⁵.	<ul style="list-style-type: none">• amputations at the base of which we can find inborn defects of the osteoarticular system, precluding the performance of motor functions³⁶,• acquired distortions limiting mobility or causing persistent pain, as well as ulcers, osteoarthritis and psuedoarthrosis threatening to undergo tumorous transformation³⁷,• aesthetic or psychological purposes, e.g. apotemnophilia³⁸

ed into primary and secondary ones. The first are performed immediately, the second, in deferred time to prepare the patient for surgery;

– relative indications, which include all situations in which the procedure is aimed at improving the functioning of motor organs and/or increasing the quality of life of a patient (Table 1)²⁷⁻³⁸.

Regardless of the type of indications observed in a given patient, the physician's decision to perform amputation should always be a last resort. It requires thorough deliberation and consideration of numerous social, psychological and economic complications. It should also be emphasized that this procedure diametrically changes the life of not only the patient, but also his/her relatives³⁹. In connection with the above, the physician deciding on the type and extent of amputation must demonstrate particular insight¹².

Typology and range of limb amputation

Depending on the length of time from the occurrence of indications to perform surgery, and the surgical intervention itself, traumatic and planned amputations can be distinguished. Trauma amputation is most

often caused by unfortunate accidents that require immediate bandaging. In their course, the degree of amputation is imposed by the extent of damage and the need to select an appropriate prosthesis⁴⁰. On the other hand, planned amputations are carried out at a time appointed by a doctor and in accordance with previously adopted medical objectives¹².

Due to the manner in which the procedure is performed, open and closed amputations are distinguished. The first include guillotine and circular amputations²⁷. Amputation leaving an open stump is performed relatively rarely and consists in severing the limb without closing the surgical wound, which aims to minimize the potential effects of abundant tissue purulence and necrosis⁴¹. Wound closure takes place a few days or even weeks after the first surgical treatment and involves the necessity to properly shape the stump⁴². This method is used in patients with massive crushes and extensive anaerobic infections³⁷.

Closed amputation, or otherwise referred to as definitive, involves immediate suturing of the surgical wound. This technique is used in patients with no inflammatory changes in the area of planned amputation and with a satisfactory degree of blood supply to the operated tissues¹⁵.

"Myoplastic" and "traditional" techniques are also worth mentioning. They are mainly different from each other in the method of forming the cutaneous-fascial-muscular stump. In the first case, above the extremity of the exposed bone, the operator combines opposing muscle groups, which should also be attached to the bone. As a result, the myoplastic technique allows to obtain a strong and painless stump with proper blood supply, which, in the future, will enable the patient to use full-contact prostheses⁴³.

Apart from the choice of time and manner of performing the procedure, the range of amputation is also very important. In this context, two basic types can be mentioned, that is, small or extensive amputations. Extensive amputations include surgery performed below elbow level, below knee level and higher. Surgeries carried out below these limits are called small amputations²⁶.

Slightly different factors determine the range of amputations performed in the area of the upper and lower limb. In these amputations, one should be guided by the principle of "*save as much as possible*", especially regarding the thumb, which fulfils an essential role in grip mechanics via opposition to the index finger. In turn, the level of lower limb amputations depends on their supportive and

locomotive functions, and should create the possibility of optimal prosthetic application³⁷. In this context, the so-called amputation blind spots should also be borne in mind.

Regular surgical practice proves that upper limb amputations are most often performed in the case of traumatic indications, most of which are affected by finger injuries. On the other hand, the most frequently registered indications for performing amputations among the lower limbs are chronic illnesses resulting in ischemia and necrosis, which affects up to 90% of patients³⁷.

PHANTOM PHENOMENA – DEFINITION, DIVISION AND HISTORICAL OUTLINE

The amputee is faced with an extremely difficult adaptation period, during which s/he should strive for a maximum degree of independence. Unfortunately, this struggle is often accompanied by various types of pain and sensations located within the lost limb and/or stump, which may lead to depression, a feeling of hopelessness and deterioration of quality of life due to its chronic nature.

In literature on the subject, these types of phenomena are variously defined and named, but specialists most often use the terms: phantom sensations, phantom phenomena, phantom limb pain (PLP) and phantom limb syndrome (PLS)^{9,10}. It is worth noting that the word "phantom" was first used by the American neuroscientist Silas Weir Mitchell (1829-1914) in 1871^{88,44}, and the medical issue itself was already presented in 1551 by the prominent French physician Ambroise Paré⁴⁵.

The occurrence of phantom syndromes in amputees is extremely common. This problem affects from 70%¹⁰ to even up to 98% of patients⁴⁶, or according to other authors, from 45%-85% of patients after amputation of one or both upper and lower limbs^{5,47}. According to Kuffler⁵, phantom pain usually occurs at two time periods: up to a month following amputation and later, approximately a year after surgery. Although

in most patients the frequency and intensity of phantom pain decreases over time, severe pain persists in 5%-10% of them⁴⁵. These ailments may also occur immediately after the surgery or only after a few years. Interestingly, this type of discomfort usually disappears over time, usually 2 to 3 years, but may also assume chronic form⁴⁸. According to Kuffler⁵, if the pain persists beyond 6 months, the prognosis regarding its decrease is unfavourable.

Hypothetical pathomechanisms of phantom phenomena

Initially, it was thought that the bases of phantom phenomena are mental disorders¹⁰. Interestingly, from a biological point of view, the issue of phantom sensation was for the first time observed by Ambroise Paré, who claimed that pain in amputated limbs is a consequence of irritation of nerve endings located within the stump⁵³.

Currently, there are many scientific theories attempting to explain the pathomechanisms of phantom phenomena following amputation. It seems that phantom pain appears and is sustained by various mechanisms⁴⁵. This pain induces changes in particular parts of the nervous system (peripheral axons, dorsal root ganglia, spinal cord and cerebral cortex) occurring at two separate periods following amputation⁴. The first takes place within the first month after amputation and seems to be a key period in the development of phantom pain. The second, occurring at a later period, is associated with changes in neurons and neurological circuits responsible for its maintenance. Such a state of affairs is caused, among others, by loss of afferent stimulation and collateral hyperplasia of the spinal cord's neurons, increased activity of inflammatory cells in the ganglia, hyperactivity of nociceptive neurons and formation of neuroma in the stump, including those reported by Robert Melzack and Vilayanur Ramachandran⁴.

Neuromas are pathological inflammatory lesions in the area of the nerve endings that are sensitive to

various stimuli, such as, for example, touch- or temperature-related changes. They occur in 13% to 32% of patients after amputation and greatly hamper the process of fitting a prosthesis^{5,15}. The truthfulness of this concept is supported by, among others, the intensification of phantom phenomena in stressful situations, in which released norepinephrine translates into increased activity of cells forming neuroma. In turn, the low effectiveness of the stump re-operation denies the thesis for this reason. Therefore, these treatments should be preceded by broadly understood neuropathic pain therapy⁵.

The next theory assumes abnormalities in the functioning of the spinal cord, which may include, among others: its damage, hyperactivity of cells, changes in discharge patterns and misinterpretation of signals via the cerebral cortex⁴⁹. This idea seems to not be supported by the fact that phantom phenomena are also experienced by individuals with tetraplegia.

In 1990, Robert Melzack proposed a different concept for explaining the pathomechanism of phantom phenomena, the so-called neuromatrix concept⁵⁰. According to its assumptions, there is a "neuromatrix" in the brain, the task of which is not only to respond to the stimuli that reach it, but also to generate a feeling that the human body is a whole and belongs to it. All kinds of disruptions in the functioning of this "neuromatrix" may contribute to the occurrence of phantom phenomena.

According to Ramachandran, the basis of phantom sensation lies in re-organization among the areas of the somatosensory cortex, which occurs due to amputation. The somatosensory cortex is located in the frontal lobe. Each area is responsible for sensory sensation from different parts of the body. Work is similarly organized, close to the motor cortex. In a situation when a certain zone stops receiving impulses due to e.g. amputation, it takes over the function of neighbouring areas. In connection with the above, it may happen that a patient following hand amputation will experience phantom sensations, while for example, stimulating certain are-

as of the face⁵¹. Recent research confirms the phenomenon of cortical remodelling after amputation of the upper limb, consisting in partial invasion of the zone representing the mouth, on the adjacent expiring zone representing the amputated hand⁵².

Types of phantom phenomena

The typology of phantom phenomena most frequently quoted in literature on the subject was formulated at the end of the 20th century. According to its assumptions, two basic types of phantom phenomena are distinguished: phantom sensations and phantom pain⁵³.

Phantom sensations

Phantom sensations can be defined as a group of illusory and painless sensory experiences, including part or the whole amputated limb (Figure 1 and 2). They can take on a variety of forms, including: phantom limb sensation and phantom limb awareness⁵⁴. The first are experienced by patients as sensory sensations, such as tingling, itching, tickling, feeling of movement, a feeling of warmth or cold⁵⁵. In the second case, patients feel the presence of the lost limb⁵⁶. This phenomenon is often accompanied by so-called telescoping, i.e. progressive shortening or lengthening the felt phantom limb (the closest part of the phantom is perceived as missing, e.g., the tibia, while the distal part e.g. the foot, as located at the base of the stump)⁵⁷⁻⁵⁹. This may be due to smaller representation in the cortex of proximal parts of the limbs with respect to the distal parts. In addition, it has been observed that lower limbs have a faster telescoping tendency than the upper one, which also supports the above-mentioned theory⁴⁸. The dynamics of telescoping greatly varies in amputees. In general, it develops within the first weeks after amputation and progresses gradually over many years, but it can also develop within a few hours⁵⁸. Telescoping is important from a clinical point of view because it is usually associated with an increased level of phantom pain⁵⁹.

An additional phantom sensation may also be voluntary limb movement.

Phantom pain

Phantom pains, i.e. painful sensory sensations, are most often located in distal parts of a non-existing

limb or other amputated body parts. It was believed that this problem affects only 2% of patients, however, more recent studies indicate that this problem occurs in over 4/5 patients following amputation^{4,5}. It is worth emphasizing that these pains appear relatively quickly and as time passes, they usually weaken and sometimes even disappear completely⁴⁵.

It is assumed that the basis for the occurrence of phantom pains are pathological remodelling processes including changes in the peripheral and central nervous systems, however, the details of the pathomechanisms mentioned above are still not fully understood^{4,60}. There are a number of factors that can increase the risk of phantom pain, including, among others:

- the presence of severe and/or chronic pains in the pre-operative period in the area of the affected limb,
- stump pain,
- amputation due to crushing, impaired peripheral circulation or tissue necrosis,
- poor condition of stump healing,
- so-called post-traumatic "pain memory",
- iatrogenic errors in the form of, for example, an incorrectly bandaged stump,
- infections and other complications within the area of the postoperative wound,
- general poor mental state of the patient, including, for example, anxiety disorders, depression^{61,62}.

The nature of phantom pain can be extremely diverse, hence, numerous classifications have been created for its more precise description. Among the terms describing pain often mentioned by patients after amputations, the following should be mentioned: stinging, burning, pricking, cutting, vibrating, contractive, compressive¹¹, burning twisting, dull, tickling, itching, stabbing, in the form of electric discharges, paralyzing, freezing or "pain as before surgery"^{7,8,63-70}. It should be noted that due to the unwavering interest in the subject-matter, the presented typology is an "open list". This is confirmed by information included in the mate-



Figure 1
Incomplete phantom sensation involving feeling a given body part – in this case, amputated toe and heel

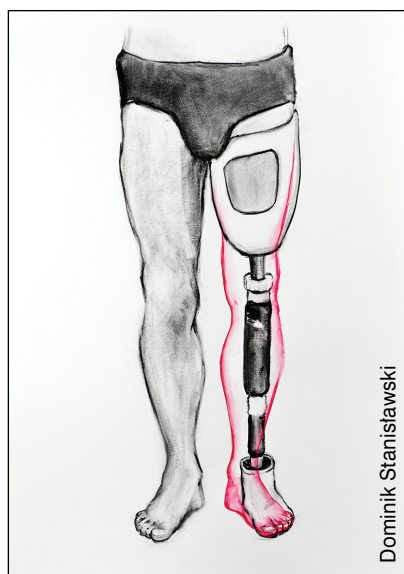


Figure 2
Phantom sensation consisting in sensing the limb after applying a prosthesis. However, the phantom phenomenon does not always perfectly correspond with the prosthesis

rials of the British Limbless Association, according to which, along with sensory sensations, stump and phantom pain, phantom phenomena also include:

- sensations consisting in feeling the presence of e.g. a watch or ring on the amputated hand (super added phantoms)⁷¹ (Figure 3),
- sensory phenomena appearing in the amputated limb as a result of stimulation of another part of the body, e.g. tingling sensation in imaginary fingers during shaving (referred phantom sensation).

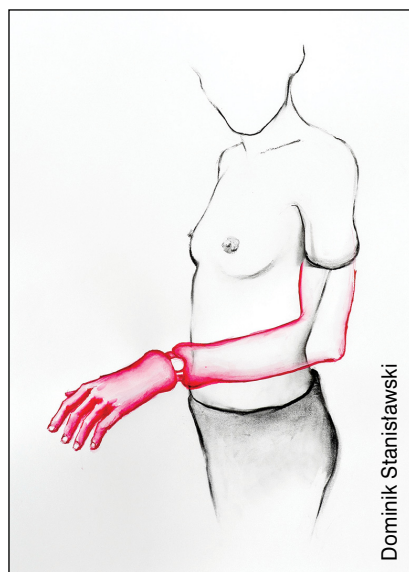


Figure 3

Phantom phenomenon in the form of painful feeling of pressure from wrist-watch

Stump pain

Stump pain is often classified in literature as phantom pain, which makes diagnosis and assessment of both types of pain indistinct. For this reason, it is worth emphasizing that stump pain concerns only the existing part of the amputated limb, while phantom pain – only its non-existent part.

Stump pains may appear at any time after surgery and are observed in approximately 60% of limb amputation patients. They are usually receptor-like, but sometimes also have a neuropathic basis⁶⁰. The most frequent causes of this type of pain include:

- changes in the blood vessels caused by, among others, progres-

sion of atherosclerosis, thromboembolism,

- inflammation of the stump tissues, including, among others, inflammation of bone tissue and pressure ulcers, occurring as a result of long-lasting pressure,
- incorrectly shaped stump, complications after transplantation of the skin onto the stump (hard adhesions or unmatched skin patches) and/or surgical technique errors (Photo 1-4),
- proliferative factors, e.g. neuromas and callus produced during the process of stump healing,
- further development of cancerous tissues (in patients after amputation of tumorous etiology),

- mechanical factors, including, among others, unskilled bandaging forming the stump, errors in prosthesis adaptation, changes in the volume of the stump (e.g. in dialysis patients) and associated prosthetic difficulties (Photo 5),
- others, such as joint pain, high body mass and dermatological changes within the area of the post-operative scar⁶⁰.

It is also worth mentioning other post-amputation complications involving the stump, such as jumpy stump, a syndrome of mechanical disorders of unknown origin, which manifests itself in a series of cramps of various nature, e.g.: myoclonic, choreic or trembling⁷².



Photo 1

Incorrectly formed stump at the height of 1/3 of the middle right thigh with incorrect location of the amputation wound on the surface of the loaded stump with its separation



Photo 2

Incorrectly formed stump at the height of the right pertrochanteric thigh bone with the disproportion of the length of the bone stump with its emergence, to the cutaneous-muscular stump



Photo 3

Incorrectly formed right shin stump with malformed loading surface and improperly selected height of amputation in contused tissues complicated by necrosis



Photo 4
Fistula with exposed distal part of the tibia

Some factors influencing the frequency and intensity of phantom phenomena

Numerous factors were found showing a connection with the occurrence or intensity of phantom phenomena in patients following limb amputation (Table 2)^{6,60,73-75}. The occurrence and intensity of phantom phenomena can also be influenced by:

- mode in which the amputation was carried out – persons who lost their limbs during injuries are more



Photo 5
Strongly reddened skin on the stump of the right lower limb in the area of the subpatellar support and the entire surface of the left lower limb stump indicate incomplete adaptation of the prostheses

exposed to phantom phenomena than those for whom the amputation was planned⁴⁸,

- type of prosthesis^{76,77},
- lateralization – patients who have lost their dominant limb are more likely to experience phantom phenomena⁷⁸,
- body part subjected to amputation (concerning the upper limb more often)^{4,79},
- the range of amputation – phantom sensations are stronger in patients with amputation reaching above the elbow joint and

- weaker in patients where the stump does not reach the knee joints⁸⁰,
- time of day – the intensity of phantom sensations is often stronger in the evening and at night⁷⁰.
- sex – they occur more frequently in females^{4,81},
- occurrence of limb pain before amputation⁸²,
- time from amputation⁸³,
- lack of physical activity⁸⁴.

Treatment of phantom phenomena

Painless phantom sensations rarely constitute a clinical problem and therefore, the treatment of phantom phenomena is most often related to painful sensory sensations and phantom pain. To date, no fully effective method of treatment has been developed, permanently alleviating phantom pain and improving the quality of life of patients with this type of pain⁸⁵. Currently applied treatment methods of painful phantom sensations can be divided into: pharmacological, neurosurgical, physical, neurorehabilitative and psychotherapeutic^{5,7}. Pharmacological treatment (local anesthetics⁸⁶, acetaminophen⁸⁷, NSAIDs⁸⁷, antidepressants^{88,89}, opioids, anticonvulsants^{9,90,91}, NMDA (N-methyl-D-aspartate) receptor antagonists^{92,93}, calcitonin^{94,95}, beta blockers, calcium channel blockers^{9,96})

Table 2
Reasons for intensification of phantom phenomena with particular reference to phantom pain⁶⁹

Factors intensifying phantom phenomena (with particular emphasis on phantom pain)
<ul style="list-style-type: none">• chronic emotional stress^{6,60,73},• anxiety⁷⁴,• depression^{4,6},• feeling of uncertainty⁶,• body acceptance issues⁶,• lack of psychological support⁶,• sleep deficiencies and disorders⁷³⁻⁷⁵,• fatigue^{60,74},• sensory-motor disturbances⁷³,• defecation⁷³• micturition disorders⁷³• ejaculation⁷³,• coughing attacks⁷³,• yawning⁷³,• stump manipulation⁶⁰,• mechanical or thermal stimuli^{60,74} (with properly bandaged stump, the risk of a phantom syndrome is probably reduced, whereas exposure to various stimuli increases this risk),• climate changes^{6,73},• total relaxation of the body during rest⁷³.

does not always turn out to be effective or, due to the existing undesirable side-effects, cannot be used⁵.

Apart from pharmacotherapy, other therapeutic methods and techniques are used to reduce the intensity of phantom pain and to improve patients' quality of life^{4,5}. These include: mirror visual feedback (neuropsychorehabilitative method)^{9,69,77,84,97-103}, electrostimulation therapy (most often Transcutaneous Electrical Nerve Stimulation, TENS)^{9,60,77,84,101,103-105}, transcranial stimulation of the motor cortex (Transcranial Direct Current Stimulation, tDCS)¹⁰⁴, Repetitive Transcranial Magnetic Stimulation (rTMS)^{106,107}, ultrasounds^{77,103}, thermotherapy^{7,9,101}, acupuncture^{9,60,84,108,109}, massage¹⁰³, relaxation consisting of: muscle relaxation, vasodilatation, circulation improvement, reduction of contractive and burning pain^{7,60,77,84}, psychotherapy^{60,84,101,108}, peripheral desensitisation, Eye Movement Desensitization and Reprocessing (EMDR)¹¹⁰, imagery and hypnosis¹¹⁰, invasive interventions: deep brain stimulation, spinal cord stimulation, excision or surgical correction of painful neuromas, sympathectomy, transposition of the nerve stump into the muscle tissue or subcutaneous vein, dorsal column stimulators, damage to the posterior root input site^{5,7}, becoming accustomed to one's new body image and to the fact of losing a limb⁷. As a supplement to therapeutic methods, environmental treatment may be helpful, consisting in keeping diaries taking the intensity of phantom pain into account depending on weather conditions, diet, psychological tension and behaviour^{7,111}.

Also, stump bandaging routinely used after amputation procedures¹¹², aimed at shaping and reducing edema, changing the body position of the patient and the task of putting on and removing the prosthesis, can modify phantom pain^{9,101,103,108}.

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