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PODSTAWY NEUROREHABILITACJI - UDAR MÓZGU - MODUŁ 2

Szkolenie obejmuje warsztaty praktyczne z zakresu diagnostyki funkcjonalnej pacjentów, podstawowych problemów strukturalnych i funkcjonalnych oraz propozycje terapii: reedukacji funkcji kończyny górnej i dolnej oraz wybranych strategii rehabilitacji. Omawiane jest również zagadnienie dysfagii, w tym objawy zaburzeń połykania, testy i ocena zaburzeń, zasady bezpiecznego karmienia, strategie terapeutyczne, ćwiczenia miofunkcyjne oraz specjalne techniki ułatwiające połykanie.

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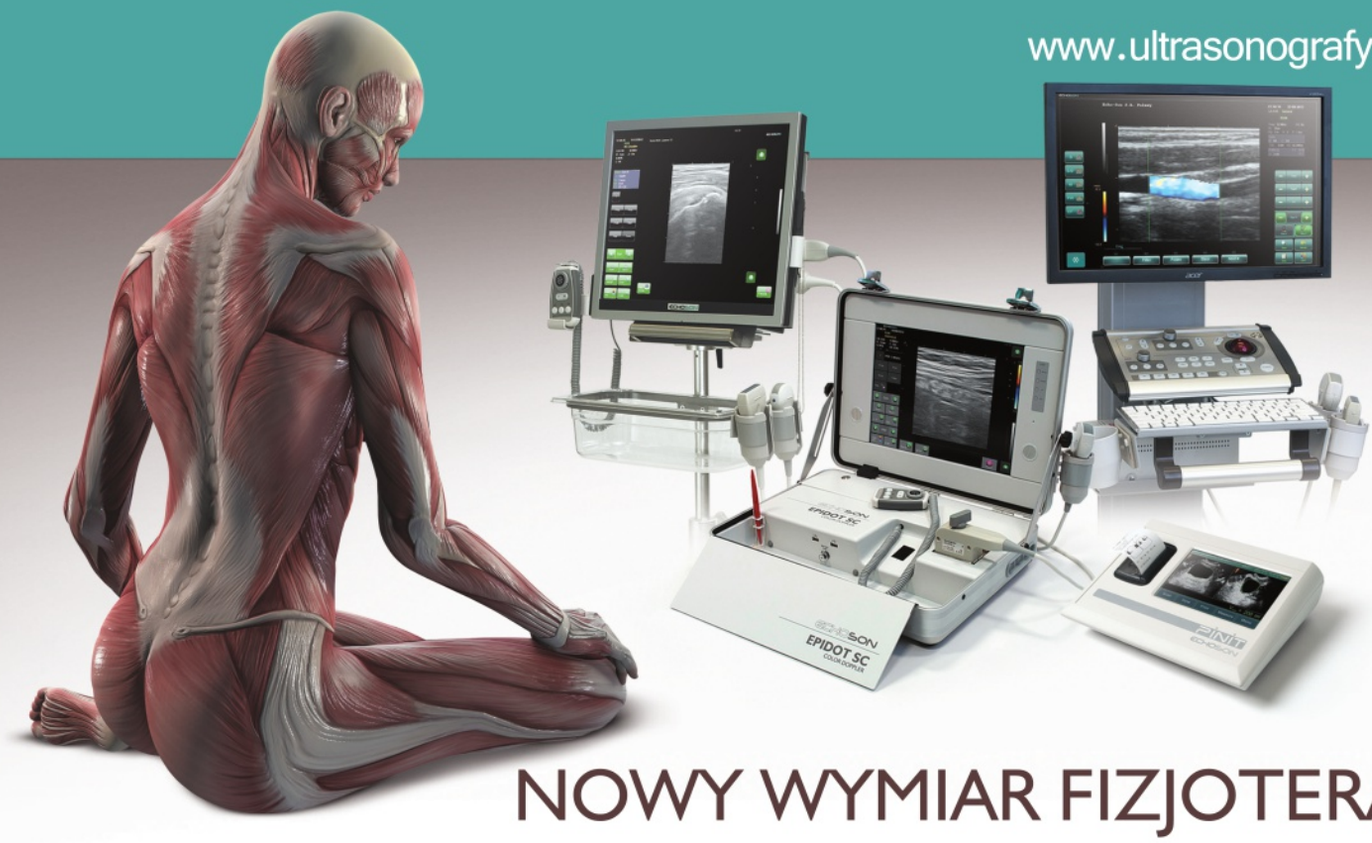

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Zastosowanie terapii wymuszeniem ruchu u pacjentów po udarze mózgu

The Application of Constraint-Induced Movement Therapy in Patients after Stroke

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Streszczenie

Co roku, około 10,5 mln osób na świecie doświadcza pierwszego udaru mózgu, czego częstym skutkiem jest niepełnosprawność fizyczna. Około 70-80% doznaje, w różnym stopniu, zaburzenia funkcji kończyny górnej, co znacznie pogarsza codzienne funkcjonowanie. W ostatnich latach rozwijano wiele różnych sposobów usprawniania po udarze, zwłaszcza tych, które wpływają na plastyczność mózgu. Należy do nich m.in. terapia wymuszeniem ruchu (CIMT, Constraint-Induced Movement Therapy), która bazuje na aktywnym udziale pacjenta. Podczas intensywnych treningów niedowładnej kończyny, druga, mniej zajęta kończyna, jest unieruchamiana. Wszystkie komponenty CIMT wspomagają zjawisko plastyczności mózgu. Przeprowadzono wiele badań, w których udowodniono, że terapia CIMT (oraz jej modyfikacja mCIMT) uważana jest za jedną z najbardziej efektywnych form kinezyterapii poprawiającą funkcję niedowładnej kończyny górnej po udarze. Terapia CIMT jest przeznaczona głównie dla pacjentów z łagodnym i umiarkowanym niedowładem kończyny górnej, stosowana jest zwykle w okresie przewlekłym po udarze mózgu.

Słowa kluczowe:
udar mózgu, niedowład kończyny górnej, plastyczność mózgu, terapia wymuszeniem ruchu (CIMT)

Abstract

Each year approximately 10.5 million people worldwide experience their first stroke. This often results in a physical disability. Approximately 70-80% of these suffer from an upper-limb dysfunction of some kind which can substantially restrict day to day functioning. In recent years a number of different forms of post-stroke rehabilitation have been developed many of which aim to harness the phenomenon of neuroplasticity. These include, amongst others, Constraint-Induced Movement Therapy (CIMT), which relies on the active participation of the patient. During intense workouts of the paretic limb, the unaffected limb is immobilized. A number of studies have been conducted which have proven that CIMT (and its modification, mCIMT) is one of the most effective forms of kinesitherapy at improving the function of the paretic upper limb after stroke. CIMT is intended primarily for patients with mild or moderate upper limb paresis and is usually undertaken in the chronic period after cerebral stroke.

Key words:
cerebral stroke, upper limb paresis, neuroplasticity, constraint-induced movement therapy (CIMT)

Introduction

According to WHO, ischemic cerebral stroke is a 'clinical syndrome characterized by a sudden occurrence of focal or generalized cerebral function impairment, the symptoms of which persist for longer than 24 hours or lead to death and have no other than vascular cause' [1]. Each year approximately 10.5 million people worldwide experience their first stroke. In 5.9 million cases it is the cause of death which makes stroke the second most common cause of death and one of the major causes of disabilities amongst adults [2].

Approximately 70-80% of people suffer from some form of upper limb dysfunction post stroke [3]. Even a small reduction in the mobility of the upper limb caused by stroke significantly impairs the daily activity of these patients resulting in decreased functioning in society and a reduction in quality of life. The severity of upper limb paresis is an independent factor in the limitation of activities of daily living after stroke [2].

During the last decade much attention has been devoted to forms of rehabilitation which make use of cortical reorganization (plasticity) of the brain. It has been proven that task training, constraint-induced movement therapy, mental training, training with the participation of a robot, and virtual training are more effective than traditional methods of rehabilitation due to the active participation of the patient in these forms of therapy. They make use of motor learning principles and lead to a greater level of functional improvement than traditional forms of therapy [4].

A common phenomenon observed in patients in the first weeks and months after stroke is the nonuse syndrome of the paretic upper limb as a result of its denervation. According to the psychologist Professor Edward Taub, this type of behavior may be caused by the shock associated with the occurrence of extensive disability. Many attempts to move the paretic limb bring pain and failure which is a negative stimulus for the patient, effectively a punishment. Likewise, excessive requirements imposed by the therapeutic team may lead to the sole use of the healthy limb while performing daily activities.

The nonuse condition may persist even when the paretic upper limb is actually functional enough to be used in everyday life. CIMT can be used to reverse this phenomenon [5]. CIMT is a relatively new therapeutic method that is task- and function-oriented and based on the active participation of the patient. During intense workouts of the paretic limb, the unaffected limb is immobilized. CIMT takes advantage of the phenomenon of neuroplasticity [6] and has been shown to be the best researched form of rehabilitation of the paretic upper limb after stroke [2].

Constraint-induced movement therapy (CIMT) characteristics

The classic form of CIMT is founded on three pillars:

1) intensive task training of the paretic limb,
2) the use of behavioral techniques that are aimed at transferring the skills acquired by the patient under laboratory conditions to the real environment, the so-called ‘transfer package’ and
3) immobilization of the unaffected limb [7, 8].

The original therapy achieves the immobilization of the healthy upper limb using a glove which is worn for approximately 90% of waking time for a period of two to three weeks. During this period the paretic limb is subjected to strenuous training of gradually increasing difficulty, until at least 5 repetitions of a series are performed by the patient correctly.

Fig. 1,2,3,4. The training of the paretic limb with the immobilization of the healthy upper limb using a boxing glove

After each exercise unit points are awarded for the speed with which the patient completes the movement and the quality of movement performance. This provides the patient with feedback on the progress that they have made since the beginning of the therapy. This positive feedback is a very important element of CIMT because it allows skeptical patients to see the functional improvement of their limb, and so engender belief in their abilities and in the likely success of the treatment [9]. However, it has been shown that only 32% of patients are willing to undertake such a restrictive model of therapy [10] and, consequently, CIMT has been modified into mCIMT in which the time of intensive upper limb training is shortened to between 30 minutes and 2 hours per day, and the time of second limb immobilization is shortened to a maximum of 6 hours [11].

mCIMT therapy no longer comprises the three essential elements. It is limited to repetitive training aimed at performing specific tasks with the paretic limb. The second limb is immobilized using thermosetting scales, a mitten, or by securing it to the torso. mCIMT includes the technique of 'shaping' which helps to break the psychomotor barrier at the beginning of therapy, and at each subsequent stage of

rehabilitation, thus bringing the patient closer to reaching their goal. The patient is praised for every small step of progress in the motor function of the paretic limb and there are no critical comments in the case of failure [2, 5, 9].

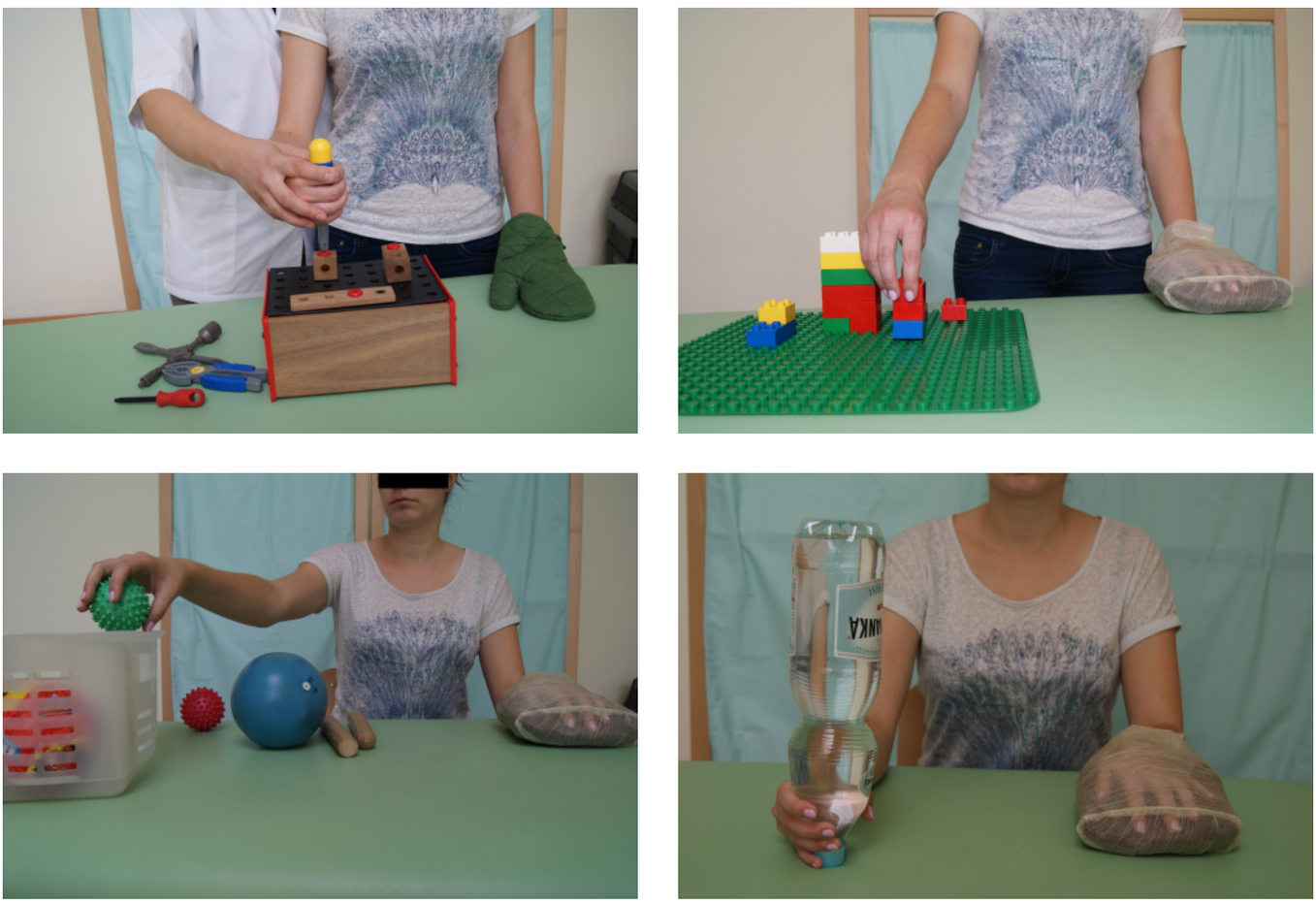

Fig. 5,6,7,8. The training of the paretic limb with the immobilization of the healthy upper limb using a kitchen glove or a special soft glove

It has been proven that the lone use of behavioral techniques in rehabilitation after stroke does not yield good results. According to Tauby this is due to immobilization of the upper limb without introducing 'shaping' [9].
Another study has been conducted to verify the effectiveness of these techniques. Thirty long term patients were divided into three groups, a CIMT group, a 'shaping' group, and an occupational therapy group. The CIMT group was enhanced by shaping, behavioral techniques and the restriction of movement in the clinic and at home. The 'shaping' group was enhanced by shaping techniques and restriction of movement in the clinic, whereas the occupational therapy group was enhanced by occupational therapy and restriction of movement in the clinic. Exercises in all groups were carried out for two weeks, 3 hours per day, 5 days a week.
The study showed that the biggest improvement in the motor function of the upper limb was obtained in the CIMT group.

The 'shaping' and occupational therapy groups achieved similar results to one another. Furthermore, it was found that CIMT in combination with shaping and behavioral techniques provides long lasting effects, observed up to 12 months after completion of therapy. The authors emphasized the effectiveness of behavioral techniques in rehabilitation of patients after stroke [12].
CIMT is a rather expensive therapy because training is conducted individually for 6 hours per day. Therefore studies have been carried out to determine whether a shorter duration of therapy would be as effective.
It has been shown that CIMT lasting 3 hours per day for more than 2 weeks is still effective, but less so than therapy lasting 6 hours each day.
Likewise, a duration of therapy of 4 weeks, for 3 hours each day, provided significant functional improvement for patients. Such a therapy regime is practicable as part of outpatient rehabilitation and is less expensive than standard CIMT [5].

Characteristics of the patients for whom the CIMT method is intended

The effectiveness of the CIMT method has only be proven in patients who meet the basic eligibility criteria of being able to actively extend the wrist, metacarpophalangeal and interphalangeal joints. Patients who have at least 20° active extension of the wrist and 10° extension in each metacarpophalangeal and interphalangeal joints have the best functional potential [13,14], whilst those who have 10° active extension of the wrist, 10° abduction or extension of the thumb and 10° extension of at least two other fingers have less functional potential [2]. Patients should repeat these movements three times per minute [15].
Research has been conducted which has shown that, despite a number of patient variables, such as paralyzed part, sex, presence of aphasia, time between stroke to beginning of therapy, degree of hand paresis, constraint-induced movement therapy achieves positive results in all patients who meet the minimum criteria of upper limb mobility. There are no groups that would achieve greater or lesser benefits from the therapy dependent on these variables [16].
To assess the results of rehabilitation with the CIMT method a number of tests are frequently used including the Wolf Motor Function Test, the Arm Motor Ability Test (AMAT), Nine-Hole Peg Test (in which the patient inserts pegs into matching holes), and the Motor Activity Log (which assesses the extent to which patients are able to apply the acquired skills after therapy in everyday life) [9].
The effectiveness of CIMT has been examined in patients with a variety of different characteristics but of 51 published studies regarding CIMT only 15 have assessed patients in the early period after stroke (up to 3 months) [2], despite the fact that CIMT can be used in the early period after stroke, and early rehabilitation is an important factor in activating the phenomenon of neuroplasticity [17]. Most of the studies describe the effectiveness CIMT in the chronic period post stroke [18, 19].
Only one study assessed the use of CIMT in patients at the very early period following stroke (very early constraint-induced movement during stroke rehabilitation, VECTORS). This study assessed CIMT up to 28 days following discharge from hospital and included 52 patients. VECTORS showed that CIMT was not more effective than traditional therapy in

the acute period post stroke. This may have been due to the minimum use, or complete nonuse, of the limb in the acute phase of stroke [20].
The effectiveness of CIMT rehabilitation in patients a long time after stroke has also been evaluated. In a study conducted at the University of Alabama in 2013, a team of psychologists, physical therapists and doctors assessed the impact of the combination of conventional therapy, such as NDT-Bobath, with CIMT in patients with hand plegia following a stroke suffered a long time previously. Before rehablitation patient fingers were clenched in a fist. Therefore, the CIMT regime was modified so that it could be applied despite the insufficient initial mobility of the fingers. The rehabilitation was divided into two phases. In phase A, which lasted 3 weeks, patients wore braces and splints, aimed at keeping the fingers in the axis. During phase B, the use of braces and splints was continued, and CIMT combined with NDT- Bobath techniques and shaping were applied.
It has been shown that the combination of CIMT and conventional therapy still brings benefits after a prolonged period following stroke, and even patients with very marked hand paresis benefit from this kind of rehabilitation [21].

Comparison of CIMT to other methods of rehabilitation after stroke

Hamzei and Binkofski conducted a study comparing the application of CIMT and the Bobath method on the improvement of upper limb function. A group of 66 patients were studied long after their stroke.
Compared to equally intense therapy using the Bobath method, CIMT was shown to be more effective. Patients rehabilitated using CIMT achieved greater improvement of upper limb function during daily activities, assessed after a week and after a year following the completion of therapy. Testimonials of patients also confirmed those results. In addition, patients who suffered from sensory loss and neglect achieved even better results after CIMT rehabilitation than previously found with a slight, clinically significant difference being demonstrated [5].
The study, undertaken in 2012, also aimed to compare the results achieved through CIMT and the Bobath method in improving the functionality of upper limb after stroke. It found that both therapies provide similar results in improving the function, quickness and quality of movement of the paretic limb. However, CIMT has proven to be more effective than Bobath therapy in terms of quality and the frequency of use of the paretic limb [22].
CIMT was also compared to NovEl intervention using repetitive TMS and intensive Occupational therapy (NEURO), which involves repetitive, transcranial brain stimulation with a low-frequency magnetic field (LF-rTMS) combined with intense occupational therapy. A group of 66 post stroke patients were assessed. Forty-four of them were assigned to the NEURO group in which they were rehabilitated for 15 days, during 22 meetings which consisted of 20 minutes of transcranial magnetic stimulation, 60-minutes of training with a therapist and 60 minutes training alone. The remaining 22 persons were also rehabilitated for 15 days using the CIMT method. The group held 11 meetings, during which 6 hours of training was conducted under the close supervision of a therapist.

The study showed greater efficiency of the NEURO method compared to CIMT. After rehabilitation using the NEURO method, patients achieved greater functional improvements in carrying out daily activities through increased mobility of the entire limb [23].

A comparison was made of how upper limb function was improved by mCIMT and what the impact of task training executed with both hands was. Thirty patients in the subacute phase following stroke (weeks 2-16) were randomly selected. The group rehabilitated with CIMT comprised of 14 patients and focused on performing tasks with one hand. The remaining 16 patients undertook task training with both hands, focusing on performing tasks with both hands. The entire study lasted 4 weeks. All patients performed an unassisted training program for 2-3 hours per day and also exercised for 4 hours per week under the supervision of therapists. Patients rehabilitated with mCIMT had to wear gloves on their healthy hands for 4 hours per day for a period of 4 weeks.

It has been shown that two handed task training was as effective in improving the function of a paretic upper limb as the mCIMT method. It was also proven that wearing the glove on the healthy hand seemed to be unnecessary for most patients in the subacute phase after stroke when the training focuses only on the paretic limb [24].

In order to assess the effectiveness of mCIMT and mCIMT combined with mirror therapy at the Medical Rehabilitation Clinic of the Medical University of Busan, Korea, 26 patients were examined in the subacute period after stroke. They were divided into three groups; mCIMT in conjunction with mirror therapy, mCIMT only, and a control group. After two weeks of therapy it was shown that the mCIMT and mCIMT combined with mirror therapy achieved more improvement in the function of the paretic upper limb than the control group. The group rehabilitated with mCIMT combined with mirror therapy showed greater improvement in precision motor functions [25].

In 2010 Sun et al conducted a study comparing the effects of botulinum toxin injection combined with conventional therapy as well as CIMT on stroke patients, more than a year after stroke, who had upper-limb spasticity. In all patients botulinum toxin type A (BTxA) was used. They were divided into two groups; CIMT + BTxA and a control group who were rehabilitated with conventional therapy + BTxA. It has been shown that the combination of CIMT with BTxA is a more efficient and safer means of reducing upper-limb spasticity (in particular spasticity of the elbow, wrist and fingers) and of improving motor functions 6 months following completion of therapy, compared with control group [15].

The influence of CIMT on the cortical reorganization of the brain (plasticity) after stroke

The aim of CIMT is the stimulation of cortical reorganization (neuroplasticity). It has been proven that intensive rehabilitation of a paretic upper limb using CIMT increases the hand representation area in the primary sensorimotor cortex as new cortical areas are activated following training. Similar reactions are seen in the healthy brain during the learning process, for instance when learning to play an instrument [5, 6, 9, 26].

The effects of intensive training on the reorganization (plasticity) of the brain were analyzed and it was found that CIMT greatly affects the initialization of the cortical reorganization processes of the brain. This partly explains the effectiveness of this therapy in patients following stroke [27].
A study was carried out to compare the impact of the rehabilitation of an upper limb through CIMT in the early and late period after stroke on the cortical reorganization of the brain. The early period included patients who suffered from stroke up to 9 months prior to starting therapy and the late period included those who suffered from stroke over 12 months before therapy. The Wolf Motor Function Test and transcranial magnetic stimulation (TMS) were used for patient evaluation. Following the completion of therapy, the group of early patients achieved greater improvements in the Wolf Motor Function Test compared to the late group. TMS indicated permanent enlargement of the motor hand representation areas in both groups however, the late group experienced greater, more dynamic growth [28].
The changes in the activity of areas as described above are important however, the physiological processes in the brain may be subject to rapid fluctuations and provide results that are not reliable. With this in mind, the impact of CIMT on structural plasticity, (increasing or reducing the amount of gray matter in the brain) was examined. After the application of CIMT, a considerable increase in the amount of gray matter in the sensory and motor cortical area corresponding to the paretic limb, both ipsi- and contralateral, was observed. The structural changes in the brain were accompanied by a significant improvement in the spontaneous use of the paretic limb in everyday life [29].

Assessment of CIMT effects longevity

It was found that CIMT conducted on patients after stroke results in improvement in the function of the upper limb during activities of daily living and the effects persist for 2 years after the conclusion of therapy [30].
Extremity constraint-induced therapy evaluation (EXCITE) was conducted at seven academic centers in the United States compared to conventional care. 222 patients in the subacute phase, who had suffered stroke between 3 and 9 months before, were examined. Patients chose to undergo therapy in order to relieve the discomfort they experienced due to the inability to freely use their upper extremity. All of them were able, to some extent, to bend their radiocarpal joints, thumbs and fingers. It was documented that directly after therapy an improvement in the speed of movement of the upper limb, frequency and quality of its use in daily activities was achieved as compared to usual care and the improvements were achieved much more rapidly. The positive effects of the therapy still persisted in these patients at one year and at two years [31, 32, 33].
The long term effects of rehabilitation through CIMT with the ‘transfer package’ and without it have been assessed. The ‘transfer package’ is a technique which was created to facilitate the transfer of skills acquired during CIMT in laboratory conditions to the conditions of daily living [34]. It is not exclusively limited to intensive limb training. It forces the patient to control the use of the paretic limb in activities of daily living. The therapist informs the patient how they should perform the given exercises and constantly encourages them to commit to ongo-

ing, intensive training. The advantages of using this type of therapy have also been described in other studies [7, 29, 35]. Patients were divided into two groups with the control group being subjected to intensive, 5 hour long CIMT training without the 'transfer package' and the intervention group undergoing equally intensive CIMT training lasting 4.5 hours each day but with the 'transfer package'. The rehabilitation of both groups was conducted on 10 consecutive days. After the study both groups exhibited improved function of the paretic upper limb however, at 6 month follow-up, only the group rehabilitated using CIMT with the 'transfer package' showed ongoing improvement in function of the upper limb relative to the group without the 'transfer package' [36].

Ryc. 9,10,11,12. Ćwiczenie porażonej kończyny górnej przy użyciu techniki „transfer package"
Fig. 9,10,11,12. The training of the paretic limb using the technique "transfer package"

CIMT as a form of home therapy

Continuity of therapy at home is of crucial importance in the rehabilitation process. Azab et al conducted a study to assess the impact of home CIMT on the improvement of activities of daily living using the Barthel scale. To this end, CIMT was adjusted to the patient's home environment and family members were trained to oversee the therapy and encourage

the patient to mobilize. Based on the Barthel scale, it was demonstrated that patients rehabilitated using CIMT at home every day for 4 weeks achieved a significant, long term improvement in the performance of daily activities compared to the group rehabilitated using other methods, including Bobath, Vojta, or PNF [37].

Fig. 13,14,15,16. The training of the paretic limb using daily activities

CIMT was delivered in the patient's home through a system of 3D games using a video game controller (Kinect from Microsoft). Analyses were made to ascertain whether such alternative CIMT would be feasible and effective. During two weeks of therapy patients played specially designed 3D games for 30 hours and held 5, 1 hour-long meetings with the therapist. The patients wore a glove for 10 hours per day which limited their use of the unaffected limb during activities of daily life. It was demonstrated that the home version of CIMT, delivered through 3D games, was effective and practicable [38].

Another study examined if hand dominance affected the continuation of effects after using home CIMT therapy in patients following stroke. The participants were divided into two groups, the first of which included patients whose paretic hand was dominant prior to stroke, and the second in

which the paretic hand was not dominant. It was found that the dominance of the upper limb has no impact on the effective acquisition of skills during CIMT. However, it was noted that the participants whose paretic hand was dominant prior to stroke achieved better long-term results in the performance of one handed tasks. In contrast the improvement in skills after task training performed with both hands persisted irrespective of the hand dominance [39].

Conclusions

At least 51 studies have been conducted to date regarding CIMT, in which 1784 post stroke patients were analyzed. The modified constraint-induced movement therapy (mCIMT) has been the subject of at least 44 studies in which 1397 patients were examined. No significant difference in the effects of rehabilitation between CIMT and mCIMT has been found. It has been proven that both therapies (CIMT and mCIMT) are the most effective forms of physical therapy in improving the function of a paretic upper limb after stroke [2].

No negative impact of CIMT on the rehabilitation of patients after stroke has been identified by these studies. All the studies show that patients undergoing CIMT achieve substantial improvements in the paretic upper limb function and in the performance of activities of daily living, and this has increased their overall life activity. The established criteria for participation in CIMT suggest that it is mainly intended for patients with mild and moderate upper limb paresis.

The authors of numerous publications on CIMT stress the fact that more research needs to be conducted regarding the rehabilitation of patients in the early period after stroke to verify which therapeutic stimuli have the best effects on the brain's recovery processes.

Moreover, in the light of the limited services provided as part of primary health care and the constantly increasing number of strokes, it is necessary to consider the cost-effectiveness of standard CIMT.

In view of the above, other forms of CIMT must be considered, such as group therapy in which one therapist supervises a group of patients, or unassisted training which is supervised remotely by means of modern technologies ('telerehabilitation'), and the effectiveness of these alternative forms compared to CIMT conducted individually [2].

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