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The effectiveness of selected Tai Chi exercises in a program of strategic rehabilitation aimed at improving the self-care skills of patients aroused from prolonged coma after severe TBI

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Background: Difficulties in self-care constitute a very common problem for patients recovering from prolonged coma after a severe TBI, and a major factor reducing their quality of life. Effective new rehabilitation programs that would help solve this problem are urgently needed. The purpose of our experiment was to evaluate improvement in this respect in a group of patients aroused from prolonged coma who participated in a goal-oriented rehabilitation program (Rehab-3), enhanced with selected elements of Tai-Chi.

Material/Methods: We examined 40 patients aroused from prolonged coma after a severe TBI, undergoing long-term rehabilitation according to a standard phased rehabilitation program. These patients were divided into two numerically even groups: a control group treated according to the standard program, and an experimental group, who received an additional goal oriented program enhanced with selected Tai-Chi exercises. The research methods included analysis of documentation (MRI, CT), a structured clinical interview, and the Standard Self-Care Scale.

Results: The experimental group achieved significant improvement of self-care skills, whereas in the control group the improvement was slight and not statistically significant. The value of co-efficient j (0.64) indicates a very strong association between the rehabilitation procedure and improved self-care in the experimental group, but not in the control group.

Conclusions: Our results confirmed that a goal-oriented rehabilitation program enhanced with elements of Tai-Chi was more effective than the standard program in improving the performance of activities of daily living.

Key words: **program of rehabilitation • activities of daily living (ADL) • brainstem contusion • goal-oriented rehabilitation • health behavior • therapeutic behavior • preventative (rehabilitative) behavior • quality of life**

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Background

Over a million people have survived a brain injury in Europe over the last five years. 71% of these are mild traumatic brain injuries (TBI), while the remainder are severe TBIs, including brain-stem contusions and brief or prolonged coma [1,2]. The possibilities of modern medicine more and more often allow surgeons to save the lives of patients with severe TBIs who not long ago would certainly have died [3–7]. The patient's life is often saved, however, at the cost of a significant reduction in its quality. In addition to serious limitations of movement, most patients experience various cognitive and emotional disturbances caused by extensive brain damage. The difficult situation faced by every patient with a serious bodily injury becomes even more difficult when, in addition to the functional deficits, the patient has also lost the ability to solve problems or to plan and perform even the simplest activities [4,5,8–10]. As the patients themselves often explain, they must “learn to live all over again” [11–13].

A person affected by a severe TBI must learn many new skills from the activities of daily living and ways of coping with challenges, some of which are entirely new (e.g. using a wheelchair), while others are activities that were mastered long ago (for example, walking and bathing), but now must be performed in completely different circumstances [4,13,14] in relation to the health behaviour, especially therapeutic behaviour, and preventative (rehabilitative) behaviour as well as to the various areas of quality of life [15]. The difficult process of learning takes place at many different times over the weeks and months that follow the TBI, any consequent surgery, hospitalizations, stays in rehabilitation centers, etc. Most patients feel at discharge that they have been left to themselves and can count on no one. No one can answer the basic question: “What now?” [11–14].

Our own clinical observations indicate that patients aroused from prolonged coma after severe TBI experience enormous difficulties in self-care. This problem constitutes one of the primary factors that significantly lower their quality of life [13,14,16–18].

Relatively few works have been written on the subject of the rehabilitation of these patients [13,14,18,19], and even fewer on the improvement of their self-care skills, which form an integral part of their quality of life [19–23]. In general, authors raise the problem of self-care skills by merely asking a rhetorical question: how to best help the patient who, having survived the worst, must now put their life back together again, though they are often disabled and unprepared for this task. The performance of even the simplest activities of daily living is often impossible because of chronic pain [20,22,23]. The patients gradually withdraw from social life, which worsens their social dependency [13,18,19]. The family is generally unprepared for the new obligations that have suddenly arisen, and

is unable to cope or - very often, unfortunately – unwilling to take on the new challenge, absent, or deceased in the same accident that injured the patient [1,13].

Neither the Polish School of Rehabilitation nor significant rehabilitation centers around the world have yet developed an effective program of rehabilitation that would make it possible for these patients to solve the problems they are facing [13,23]. Accordingly, the search is on for new and different rehabilitation programs that would provide some solutions. In recent years considerable hope has been invested in the use of selected Tai-Chi exercises in medical rehabilitation [24–31]. There have been no reports however, in world literature regarding the use of Tai-Chi exercises in the rehabilitation of severe TBI patients aroused from prolonged coma. The idea of using Tai-Chi exercises in rehabilitation arose from many years of observation and research on patients treated for other illnesses, including disorders and injuries to the musculo-skeletal system [27–31]. Tai-Chi exercises by their nature improve concentration while gently increasing the range of movement and reducing pain [29,31].

Our research hypothesis was that selected Tai-Chi exercises that facilitate the performance of particular movements would have an indirect influence on the skills of self-care. The goal of our experiment was to evaluate improvement in the performance of activities of daily living on the part of patients aroused from prolonged coma who participated in a goal-oriented rehabilitation program (Rehab-3), enhanced with selected elements of Tai-Chi, as compared to patients rehabilitated according to the standard rehabilitation program.

Material and Methods

Demographics and clinical characteristics of the subjects

Our research involved 40 patients aroused from prolonged coma after a severe TBI, who had been treated in the Rehabilitation Clinic of the Rydygier Academy of Medicine in Bydgoszcz, Poland, and the Department of Medical Rehabilitation at the Cracow Rehabilitation Center. All these patients had received long-term rehabilitation in the Reintegration and Training Center of the Foundation for Persons with Brain Dysfunctions, according to a standard phased rehabilitation program. The subjects were divided into two numerically even groups: the control group (n=20, 11 men and 9 women), who were treated according to the standard program, and the experimental group (n=20, 13 men and 7 women), who received an additional goal-oriented program enhanced with selected Tai-Chi exercises (Rehab-3).

We excluded from this study persons who were found in neuropsychological testing to have aphasia or dysarthria, severe

memory or attention deficits, or severe emotional or motivational disorders; serious clinical conditions (such as severe cardiovascular disorders, respiratory disorders, decubitus ulcers, poorly healing wounds, or other skin disorders rendering participation in the experiment difficult) were also excluded.

This selection of patients for the groups and the rehabilitation procedure were deliberately designed to verify the new program under clinical conditions by comparing rehabilitation outcomes between the patients from the experimental and control groups who were receiving the same basic rehabilitation program, with the addition of Tai-Chi exercises in the experimental group.

A large majority of the subjects were in the age bracket from 20 to 30 years. The average age in the control group was 26.3 years (SD=9.72), compared to 33.6 years in the experimental group. The immediate cause of brain injury in almost all subjects in both groups was a motor vehicle accident.

All patients from both groups had suffered a severe TBI and had been in a prolonged coma. All of these subjects had 3 points on the Glasgow Coma Scale (GCS) when admitted to the intensive care unit. The average duration of coma ranged from 21 days to 8 months, with an average of 47.6 days. During this period two patients from the control group had 3 points on the GCS, 4 patients had 4 points, 8 patients had 5 points, 3 patients had 6 points and 3 patients had 7 points, while in the experimental group, 15 patients had 3 points, 4 patients had 4 points, and 1 patient had 5 points.

Most of the subjects had a cerebral hematoma. In the control group, 13 patients had a hematoma, which in 4 patients was reabsorbed without surgery, while 9 patients were operated. In the experimental group, 10 patients had hematomas, which were reabsorbed without surgery in 5 patients, while 5 patients were operated.

Post-surgical skull defects occurred in 7 patients from the control group and 5 patients from the experimental group.

Various neurological problems occurred in both research groups. In the control group, 6 patients had epilepsy, 18 patients had headaches, 11 patients had visual disturbances, and 12 patients had dizziness. In the experimental group, 7 patients had epilepsy, 19 patients had headaches, 9 patients had visual disturbances, and 13 patients had dizziness.

Research methods

In order to measure rehabilitation outcomes we used the following research instruments:

1. Analysis of documentation – the medical history and test results, including MRI and CT;

2. Clinical interview – oriented towards the goal of the research, with particular emphasis on how the patient copes with the limitations resulting from the disease, the patient's attitude (especially self-image and sense of the future), value system, and personality, with particular emphasis on any available information about the patient's premorbid personality;

3. The *Standard Self-care Scale* [32] – consisting of the most important and complex of the basic activities of daily living: eating and drinking, washing, grooming, and dressing. Within each of these categories, three to five activities are assessed according to the patients estimated percentage contribution to their performance. The level of assistance the patient requires is specified in points according to a scale adapted from the ASIA Scale, which gives internationally accepted standards for the neurological and functional classification of spinal injuries [33]:

- 1 or 2 points – compete dependance (patient's own contribution: 0–25%);
- 3 to 5 points – limited independence (patient's own contribution: 50–75%, or independent performance under direct supervision);
- 6 to 7 points – independence (patient's own contribution: 100%, with or without adaptational devices).

The evaluation was performed by a physician specializing in rehabilitation on the basis of his own examination and the clinical interview. Points were awarded by the method of three competent judges (a physician specializing in rehabilitation, a physiotherapist, and a neuropsychologist).

Therapeutic procedure

The patients underwent rehabilitation for six weeks using a goal-oriented program which has been more fully described elsewhere [31]. The Tai-Chi exercises were conducted twice a week. The self-care test was conducted twice: once before rehabilitation was commenced and again after six weeks.

Both the patients and the bioethics committee gave their consent to the experiment.

Results

Table 1 presents the results for particular activities of self-care from both the experimental and control groups at baseline and follow-up, while Table 2 presents the combined results for self-care in both groups at baseline and follow-up.

The tables present the combined number of point scores from four tasks evaluating self care obtained by 20 patients in each of the research groups at baseline and follow-up on a scale of 1–7.

Table 1. Results for particular self-care activities in the experimental and control groups at baseline (I) and follow-up (II).

Activity	Exam	Scores							Total	Significance of differences
		1	2	3	4	5	6	7		
Eating and drinking	I	0	3	2	1	6	4	4	20	$\chi^2=2.667$
	II	0	3	1	1	3	8	4	20	p=0.912
Differences		0	0	-1	0	-3	4	0		
Washing	I	1	4	3	1	4	5	2	20	$\chi^2=3.833$
	II	0	2	5	0	4	5	4	20	p=0.671
Differences		-1	-2	2	-1	0	0	2		
Grooming	I	1	3	2	1	5	4	4	20	$\chi^2=1.311$
	II	1	1	3	1	5	4	5	20	p=1.000
Differences		0	-2	1	0	0	0	1		
Dressing	I	2	3	2	3	3	5	2	20	$\chi^2=2.691$
	II	0	2	3	3	3	6	3	20	p=0.847
Differences		-2	-1	1	0	0	1	1		
Total	I	4	13	9	6	18	18	12	80	$\chi^2=4.964$
	II	1	8	12	5	15	23	16	80	p=0.548
Differences		-3	-5	3	-1	-3	5	4		

Table 2. Combined results for self-care in the control and experimental groups.

Group	Exam	Scores							Total*	Significance of differences
		1	2	3	4	5	6	7		
Experimental	I	21	12	12	7	9	11	8	80	$\chi^2=29.722$
	II	1	9	12	8	11	11	28	80	p=0.054
Differences		-20	-3	0	1	2	0	20	x	x
Control	I	4	13	9	6	18	18	12	80	$\chi^2=4.964$
	II	1	8	12	5	15	23	16	80	p=0.548
Differences		-3	-5	3	-1	-3	5	4	x	x

* The analysis is based on the number of questions asked in the self-care score (4 test questions) multiplied by the number of subjects.

An analysis of the results from the experimental group reveals major differences between the results from baseline and follow-up, as seen in the number of point scores at the lower and upper extremes of the 7 point scale. At baseline, 21 patients received the lowest possible score of 1 point, which means that these patients were not performing tasks associated with self-care; however, the results were not statistically significant. At follow-up, only one patient received a 1 point score, which points to an increase in the self-care capacities

of the patients. At baseline, 8 patients had the highest possible score of 7 points, while at follow-up there were 28 highest possible scores, which represents a 350% increase in the self-care skills of the patients. In the case of both the lowest possible and highest possible scores, the difference between baseline and follow-up came to 20 scores. At the other levels of the scale, this difference varied from 0 to -3. The differences between the distributions of the numbers of such scores in the experimental group between follow-up and baseline were

almost statistically significant ($\chi^2=29.722$; $p=0.054$). The C_{sk} contingency coefficient was calculated at 0.621, which indicates a strong association between the rehabilitation process and the patient's psychological and physical comfort.

A similar analysis of the results obtained at baseline and follow-up by the patients from the control group showed much less differentiation. At baseline four persons obtained the lowest possible score of 1 point, which means that there were patients in this group who were not performing any tasks associated with self-care (one subject was unable to wash and three people were unable to groom themselves). At follow-up only one person had the lowest possible score, indicating improvement in self-care. At baseline, 12 persons obtained the highest possible score of 7 points, which rose to 16 scores at follow-up. The difference between baseline and follow-up in this respect was statistically significant, but not nearly as significant as in the experimental group. The differences between the distributions of scores in the control group at baseline and follow-up were not statistically significant ($\chi^2=4.964$; $p=0.548$). The value of the C_{sk} coefficient was 0.12, which indicates an almost negligible correspondence between rehabilitation process and the patient's psychological and physical comfort.

In the case of the experimental group, then, the rehabilitation program had a significant impact on the patients' self-care skills. In the control group, while there was a certain improvement in self-care skills, including motor skills, the results of the χ^2 test do not allow this improvement to be linked with the rehabilitation process. The results of calculations using the χ^2 test as presented above give only a qualitative evaluation of the outcome. In order to express in quantitative terms the association between a particular rehabilitation program and improvement in the tested functions of daily living, Yule's coefficient was applied. Since this value is calculated from a two-by-two table it seemed best, given the specific nature of the data from the experimental group, to construct this table from the number of highest and lowest possible scores, i.e. 1 and 7 points respectively. The value of Yule's coefficient calculated in this way was 0.64, which indicates a very strong association between the rehabilitation process and improvement in self-care. The corresponding value for the control group was 0.14, which indicates a non-significant association.

Discussion

The rehabilitation of patients aroused from prolonged coma after severe TBI is a relatively new problem [13,14,36,37]. Very few rehabilitation centers in the world have taken on the comprehensive treatment and rehabilitation of such patients, and

so there is little scientific documentation of the effectiveness of rehabilitation in these cases [15,34,36,37]. Moreover, as previously mentioned, no research has been done on a program of rehabilitation enhanced with Tai-Chi exercises. Accordingly the results we obtained in evaluating the self care skills of our patients using the methods described here cannot be precisely compared to the results of other research.

Our experiment showed that the introduction of a goal-oriented model of rehabilitation enhanced with selected Tai-Chi exercises significantly improved the self-care skills of patients aroused from prolonged coma after brainstem contusions. This choice prove to be accurate. On the basis of these results we can state that our rehabilitation program can be generalized and applied in the rehabilitation of this group of patients.

The patients' participation, involvement, interest, or desire to join in this complex form of rehabilitation (which is diverse and interesting in itself) is much greater and more important in comparison to the role of the patient in the standard approach to rehabilitation. The active participation of the patient, which manifests itself in an eagerness to exercise, supports the performance of activities of daily living, and thus also adaptation to life with disability. Satisfaction with one's own activity, even in conditions of major limitations, allows for some degree of recompense for the impact of chronic illness on the functioning of a disabled person [37-40].

Selected exercises from Tai-Chi, a traditional martial art form from ancient China, are safe, easy, and pleasant to perform in practice, as an essential element enriching the rehabilitation program. Although they were applied in this group of patients for the first time in clinical practice, they provided effective rehabilitation in respect to self-care skills. Thus they indirectly improved the quality of life of these patients.

The constant development of means and methods of rehabilitation similar to those proposed in the present study is an urgent need. Only in this way can we improve the situation of these patients, not only in medical terms, but also in the social, professional, and economic spheres.

Conclusions

We were able to confirm that our goal-oriented rehabilitation program enhanced with elements of Tai-Chi was more effective than the standard program in improving the patients' skills in performing activities of daily living. Selected Tai-Chi exercises constitute a new and important supplement to comprehensive rehabilitation for patients recovering from severe TBI.

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