THE DOCTORAL THESIS ABSTRACT BY MS. COJOCARU MONICA VIRGINIA

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THESIS ADVISOR: Ph.D. Professor Marcu Vasile

THESIS TITLE: ***KINETIC STRATEGIES FOR THE FUNCTIONAL REEDUCATION OF THE UPPER LIMB IN STROKES***

KEY WORDS: stroke, assessment, recovery

This paper aims to offer a comparison between the Taub method and the classical methods used for the recovery of stroke affected patients.

The classical methods used for the functional reeducation of the hemiparalysed patients have not always proved their efficacy, offering unsatisfactory results. Also, an increased difficulty in the functional recovery of the upper limb in comparison to the lower one has been observed.

New methods aimed at improving the functional recovery and reeducation of the upper limb have started to be used: the mirror therapy, mental training, the coercive restraint therapy.

This paper is intended at implementing the *coercive restraint therapy* for stroke affected adults. This therapy is based on the reorganising capacities of the brain.

The *coercive restraint therapy* that we propose as an alternative to the classical therapy can reduce or lead to the disappearance of this difference even when applied at a certain distance in time from the stroke.

The novelty brough by this paper is that it identifies, defines and describes the application of a reeducation method for hemiparalysis of vascular origin that has not been used before in Romania– the coercive restraint therapy. This is the first time that randomised research has been conducted in order to test the efects of the coercive restraint therapy, which we intend to use for the recovery of stroke affected patients. This new approach is based on cognitive neuroscientific theories, which promote and integrate the sciences who focus in the brain – neurophysiology, neuropsychology, and cognitive psychology, the latter being under an intense development process in the US and in Europe.

This research has been done at the Neuropsychomotor Recovery Department of the *'Dr. Carol Davila' Central Military Emergency Hospital* in Bucharest.
The thesis is composed of three parts:

- **The First Part** explaining the topic and the theoretical approach includes 5 chaptes about:
    - The concepts used, the relevance of and the reasons for chosing this topic
    - Previous research on stroke, as found in academic literature
    - Risk factors and the physiopathology of stroke
    - Functional evaluation in case of stroke
    - Brain plasticity and functional recovery after stroke

- **The Second Part** entitled ”Pilot Study of Modern Recovery/Reeducation Methods after Stroke” is structured into 4 chapters as follows:
    - *PRELIMINARY RESEARCH OPERATIONAL FRAMEWORK* (chapter 6) describing the assumptions, the tasks, the scope, the objectives, the hypothesis, the stages, the participants and the place of research
    - *RESEARCH METHODS USED* (chapter 7), describing the bibliographic research method, the investigation method, pedagogic observation, study case, the tests method, the statistics method, the graphic representation method
    - *THE REEDUCATION PROGRAMME APPLIED AND THE EVALUATION OF PARTICIPANTS* (chapter 8) describes the data pertaining to the active reeducation programme of the stroke affected patients and their evaluation
    - *PRESENTATION AND INTERPRETATION OF THE FINDINGS AND CONCLUSIONS FOR THE SECOND PART*

The **scope** of the preliminary study was the verification of the effects of the coercive restraint therapy on the functional deficits of adults following a stroke, with the intended result of offering them the possibility of living an autonomous life and even professional reinsertion, if the case requires.

The main **objectives** of this research pertain to highlighting the importance of national health policies in promoting primary and secondary prevention of strokes and their relapse as a means of reducing mortality; highlighting and monitoring the risk factors responsible for strokes; conducting a study focused on the effects of the coercive restraint therapy; establishing the inclusion and exclusion criteria of the participants; comparing the obtained results according to a series of determinants: age, sex, socio-demographic data (residence, profession), stroke inflicting mechanism (ischemia or haemorrhage), the dominant side of the body before the stroke, the affected part and the existing comorbidities (diabetes, hypercholesterolemia); comparing the results with the other data found in international research papers and offering landmarks for the Romanian medical community; drawing the theoretical conclusions and the conclusions arising from the analysis and interpretation of

the results in this research, as well as devising a series of recommendations pertaining to a healthy lifestyle and the development of a proactive behaviour by systematically engaging in physical exercise for reducing the risks of a stroke relapse.

Research hypothesis: After a stroke, constrained use of the upper paretic limb for accomplishing daily tasks leads to its functional recovery.

The preliminary research took place between 1st October 2012 – 1st April 2013 and consisted in 4 stages. The research was undertaken in the Neuropsychomotor Recovery Department of the 'Dr. Carol Davila' Central Military Emergency Hospital, where we work. This department has the necessary equipment for undergoing specific kinetic exercises for recovery after stroke and it also receives patients who have surpassed the acute phase from other departments in the same hospital or other hospitals.

The sample consisted in 6 participants whose selection was based on a pretesting with certain research inclusion criteria.

The research methods used led to the results presented in chapter 9.

The effects of the active reeducation programme for stroke affected patients have been highlighted by the Participant Evaluatuon – *Functional Evaluation,* the Spasticity Level Evaluation, the Evaluation of the capacity of engaging in motric tasks (Wolf Motor Function Test and Motor Activity Log), *the Evaluation of life quality*.

The conclusions following the preliminary research phase are as follows:

1. The study of risk factors, classified as unmodifiable and modifiable, has generally led to similar results as those found in other academic publications.

2. Thus, as much as the unmodifiable factors such as age and sex are concerned, the sample had an average age of 62. The negative influence of age on the functional prognosis is highlighted in most studies. The sex of the patients pointed to an increased male incidence (67%), as compared to female cases (33%).

3. The modifiable factors identified are: artery hypertension, dyslipidemia, diabetes, smoking and alcohol consumption.

Artery hipertension, dyslipidemia and smoking were present in an equal proportion among the participants (50%). One patient was suffering from diabetes, an unfortunate case since it is known that this metabolic illness has a negative impact on the vital and functional prognosis of stroke affected patients. One participant was a chronic alcohol consumer (17% of the total no. of participants).

4. After using the Taub protocol, which consists in orientating the upper paretic limb towards precise tasks through the coercive restraint of the upper healthy limb, we obtained a series of results pertaining to the patients' functional evaluation and life quality, as follows:

a) The spasticity level dropped by an average of 1.83 units, which represents a level improvement of 69%, from 2.67 before the therapy to 0.83 after. In both tests the data obtained in comparison to the average is not homogenous, but according to the nonparametric Wilcoxon test the drop in average spasticity levels is statistically relevant, $z = -2.232$, $p = 0.026 < 0.05$. The efect size index (0.64) pointed to a large and very large difference between the two tests.

b) The execution time for the 17 motric tasks comprised in the Wolf Motor Function Test was timed for both the more and the less affected limb. We observed an average of 0.03 seconds drop in the execution time of the more affected limb (a 2% progress), from 1.74 seconds before the physiotherapeutic training to 1.71 seconds after. According to the nonparametric Wilcoxon test, the average drop in task execution time is significant, $z = -2.725$, $p = 0.006 < 0.05$. The size effect index (0.47) shows a medium towards large difference between the two tests.

c) The task execution time for the less affected upper limb increased with an average of 0.02 seconds (1.2%), from 1,76 seconds before the therapy to 1,78 seconds after. The nonparametric Wilcoxon test results indicate an insignificant increase of the task execution times, $z = -1.000$, $p < 0.317 > 0.05$). The effect size index (0,17) shows a large towards very large difference between the two evaluations.

Although the increase was not important we interpreted it as the consequence of the lack of activity for the healthy limb during 90% of the time the patient was awake, and we decided to add to the actual research mental training exercises as part of the coertion restraint therapy not only for the paretic limb, but also for the healthy one.

d) The functional capacity calculated for the more affected upper limb during the execution of the 17 motric tasks included in the Wolf Motor Function Test highlighted the fact that the average score increased by 34,5% after therapy, from an initial 3.24 to a final 4.35. According to the nonparametric Wilcoxon test the increase is significant, $z = -3.416$, $p = 0.001 < 0.05$.

e) The quality of movement as evaluated through the Motor Activity Log scale improved visibly, with the medium score for the paretic upper limb of 60,6% after therapy, from an initial 2.36 to a final 3.79. The increase is statistically significant, according to the Wilcoxon test, $z = -3.647$, $p < 0.001 < 0.05$ (tabel 9.37).

f) The extent of use of the paretic upper limb, according to the Motor Activity Log scale, improved for all the participants in the preliminary research phase with an average of 44,7% at the end of the therapy. The average score increased to 3.93 at the end of the therapy, after an initial 2.71. The increase of the average score is statistically significant according to the Wilcoxon test, $z = -3.494$, $p < 0.001 < 0.05$.

g) after the life quality evaluation through the use of the Stroke Impact Scale Version 3.0 the following emerged:

- for the first item, the patients' answers to the 4 questions regarding the evaluation of their force before and after the therapy after the stroke does not differ significantly, according to the square-Chi test, $p = 0.583 > 0.05$, for $\chi^2 = 1.949$ and 3 degrees of liberty;

- for the second item, the square-Chi test results with $p = 0.021 < 0.05$, $\chi^2 = 7.721$ and df=2 degrees of liberty show that the participants' answers to the 7 questions regarding the memory and cognition evaluation before and after the therapy differ significantly;

- for item no. 3, the square-Chi test shows that the participants' answers to the 9 questions about how they felt, their mood changes and their ability to control their emotions after the stroke does not differ significantly before and after the stroke. The values obtained after the square-Chi test are $p = 0.218 > 0.05$, for $\chi^2 = 5.752$ and df = 4.

- for item no. 4, the participants' answers to the 7 questions about their ability to communicate with others, as well as their ability to comprehend what they read and hear in a conversation highlight the statistically significantly different results before and after the therapy. The results of the square-Chi test are $p = 0.039 < 0.05$ for $\chi^2 = 6.674$ and df = 2.

- for item no. 5, the square-Chi test for the 10 questions regarding the tasks that the participants could accomplish in an ordinary day shows that their answers differ in a statistically significant manner before and after the kinetic programme. This is supported by the significance threshold value $p = 0.011 < 0.05$, for $\chi^2 = 13.021$ and df = 4.

- for item no. 6, the participants' answers to the 9 questions regarding their ability to walk inside and outside of the home show that they differ statistically significantlly before and after the therapy, according to the square-Chi test applied; the significance threshold is $p = 0.021 < 0.05$, for $\chi^2 = 9.706$ and df =3.

- for item no. 7, the significance threshold after applying the square-Chi test is $p = 0.002 < 0.05$, for $\chi^2 = 16.895$ and 4 degrees of liberty, which proves that the participants' answers to the 5 questions about their evaluation of their ability to use their most affected upper limb before and after the stroke differ in a statistically significant way.

- for item no. 8, the statistical significance of the square-Chi test for the 8 questions regarding the way in which the stroke affected their ability to engage in everyday tasks which they do on a normal basis and helps them have a purpose in lifeled to the conclusion that the participants'answers, before and after the therapy, do not differ significantly from a statistical point of view, having a statistic threshold value of $p = 0.534 > 0.05$ for $\chi^2 = 3.141$ and df = 4.

- for item no. 9, the patients' autoevaluation, on a scale ranging from 0-100, regarding their recovery after the stroke shows an average increase of 16.66 points, from an initial 61.67 to a final 78.33 after the recovery therapy. The

Wilcoxon test shows that the diference between the averages equivalent to the increase in the recovery degree is statistically significant, with a statistic threshold of $p = 0.023 < 0.05$, for $Z = -2.271$.

All these results confirmed the hypothesis of the research and motivated us to continue our scientific inquiry in this direction.

In conclusion, the coercive restraint therapy is a reliable alternative to the clasic methods of recovery after stroke.

For all the results that we obtained there is a correlation between the levels of the initial and final tests, all the correlations being positive. The results that emerged, their statistical processing and their interpretation constitute the research assumptions in the third part of the thesis and recommend the continuation of research in this area.

- **Part Three**, "CONTRIBUTIONS TO THE FUNCTIONAL RECOVERY/REEDUCATION IN STROKE", structured in 4 chapters, presents the actual research based on the Taub method and the kinetic programmes specially made and customised for stroke affected patients, with the aim of verifying our hypotheses.
  Part Three of the thesis consists in: THE EXPERIMENTAL RESEARCH DESIGN (chapter 10), THE DESIGN OF THE FUNCTIONAL RECOVERY/REEDUCATION OF THE UPPER LIMB (chapter 11), THE PRESENTATION, ANALYSIS AND INTERPRETATION OF THE RESULTS (chapter 12), and CONCLUSIONS.

The main aspects of the previously mentioned chapters are detailed below.

The scope of the actual research was the consolidation of the conclusions of previous research by highlighting the aspects of the coercive restraint therapy doubled by mental training applied to a larger group of participants.

The central objective consists in adapting and valorising the coercive restraint therapy as part of the reeducation, readaptation and reinsertion programme for stroke affected patients, visible in the conditions of the confirmation of its efficiency.

The tasks of the actual research

The tasks for the actual research are found in the third part of the thesis and consist in:

- Highlighting the relationship between the modifiable and nonmodifiable risk factors and the clinical development of the patients under therapy;
- Reducing the gravity of post-stroke injuries by promoting a new therapeutic method: the coercive restraint method with mental training;
- Creating a homogenous group of patients by applying the inclusion and exclusion criteria established during preliminary research;
- Designing the application of the coercive restraint therapy;

- Selecting the elements for mental training;
- Applying the recovery/reeducation programmes;
- Evaluating patients with particular tests/scales;
- Collecting and interpreting the data;
- Comparing the results obtained for functional evaluation and life quality amongst the group and establishing potential correlations between the modifiable and nonmodifiable risk factors: age, sex, spasticity level, quality of movement, amount of usage etc.
- Formulating long term recommendations regarding the lifestyle that the patient has to adopt once at home.

Research hypotheses

Given the fact that approximately 80% of Western medical recovery specialists use the Bobath concept, in a more or less rigurous way, for reeducating hemyparalises after stroke, following the new reeducation trends for ameliorating the specific aspects of this affliction we propose the coercive restraint therapy as an alternative and forward the following hypotheses:

1. ***When the coercive restraint therapy, consisting in precise motric tasks doubled by mental exercising, is applied to stroke affected patients, , the spastic muscles of the affected upper limb ensure a functional reeducation capable of offering independence for everyday tasks.***
2. ***The physical exercises programmes for the less affected, but also less constrained limb lead to an increase in its functional capacity, a fact highlighted by the execution times for the motric tasks.***
3. ***The specific programmes of active reeducation lead to an increased life quality for patients with secondary injuries after stroke.***

Patients' learning, behaviour and motivation seem to be determinant factors in using this method.

The stages of the actual research

The actual research in the third part of the thesis spread between 2013 and 2015 and is comprised of stages 6-8 of the whole scientific endeavour.

Stage 6: The progress of the actual research with the application of the Taub method coupled with mental exercising to a larger group of patients affected by stroke (April 2013 – March 2015).

Stage 7: The analysis and interpretation of the emerging results (May 2015).

Stage 8: The writing up of the thesis (2014-2015).

Participants and place of research

The participants included in the research based on their informed consent were selected from the patients who came to the Neuropsychomotor Recovery

Department of the *'Dr. Carol Davila' Central Military Emergency Hospital* and who underwent kinetic therapy between April 2013 and March 2015, having been diagnosed with post-stroke hemiparesis. The group of participants included in the research amounted to 14 persons.

Research methods used in the actual research: documentation, observation, conversation, experiment, evaluation, statistical-mathematical processing, the graphic method.
Participant evaluation was done based on certified scales, also used in prelimiary research, and was aimed at:

1. Functional evaluation using a series of approved scales, as follows:

- *The Modified Aschworth Scale* for spasticity evaluation;
- *The Wolf Motor Function Test* (WMFT) with 17 items, recommended for the evaluation of the motor function of the paretic upper limb; the items pertain to certain simple movements of the paretic upper limb, movements that involve the shoulder, the elbow, the fist, the hand or the ensemble movement of these articulations; the execution time and the functional capacity are measured (in seconds) based on a score given in accordance with the possibility of executing the moves;
- *Motor Activity Log* (MAL) which offers quantitative and qualitative information on the usage of the paretic limb in executing 14 everyday tasks; the dificulty of the execution shows the lack of usage of the paretic limb.

2. Life Quality Evaluation using the *Stroke Impact Scale version 3.0*, a questionaire in which we marked with an X the initial possibilities, and with a Y the final ones.

THE CONTENT OF THE FUNCTIONAL RECOVERY/REEDUCATION OF THE UPPER LIMB PROGRAMME (chapter 11) consisted mainly in the intensive Taub Training and Mental Exercises Training.

THE PRESENTATION, ANALYSIS AND INTERPRETATION OF RESULTS (chapter 12) includes both individual and group results.
The results were centralised and interpreted from various points of view. The first analysis was intended to highlight the presence of the risk factors classified as *modifiable* and *nonmodifiable*.

Results correlations

I. Of the parameters considered for the analysis, ***The Pearson Correlation*** shows a series of statistically significant correlations. ***The level of spasticity*** significantly corelates with the following parameters:

1. Time of task execution, substantial *positive* association, significance threshold p=0.018 <0.05, for r = 0.621. The coefficient of determination r^2= 0.386 shows a strong link between the two parameters.
2. Functional capacity, strong *negative* association, significance threshold p=0.003<0.001<0.05 for r = -0.728. The coefficient of determination r^2= 0.530 shows a very strong correlation between the two parameters (tabel 12.67).
3. Quality of movement, very strong and *negative* association, statistic threshold p<0.001<0.05, with r = -0.909. The coefficient of determination r^2= 0.826 shows a very strong correlation between the two parameters.
4. Amount of usage, substantial *negative* association, statistic threshold p=0.006<0.001<0.05, for r = -0.691. The coefficient of determination r^2= 0.477 shows a very strong correlation between the two parameters.
5. Life quality, substantial *negative* association, statistic threshold p=0.027<0.05, for r = -0.588. The coefficient of determination r^2= 0.346 shows a strong correlation between the stasticity level and the two parameters.

I. ***The functional evaluation of the affected upper limb –*** besides the *level of spasticity*, time of task execution correlates significantly with the following parameters:
   1. Functional capacity, affected upper limb – very strong *positive* association, statistic threshold p<0.001 < 0.05, for r = -0.862. The coefficient of determination r^2= 0.743 shows a very strong correlation between the two parameters.
   2. Quality of movement, very strong *negative* association, statistic threshold p=0.005<0.05, with r = -0.707. The coefficient of determination r^2= 0.500 shows a strong correlation between the two parameters.
   3. Amount of usage, substantial *negative* association, statistic threshold p=0.017<0.05, with r = -0.623. The coefficient of determination r^2= 0.388 shows a strong correlation between the two parameters.

II. ***Functional capacity of the affected upper limb –*** besides the *spasticity level* and *the functional evaluation of the affected upper limb – time of task execution* it correlates significantly with the following parameters,*:*
   1. Quality of movement, very strong *positive* association, statistic threshold p=0.002<0.05, with r = 0.751. The coefficient of determination r^2= 0.564 shows a strong correlation between the two parameters.

2. Amount of usage, substantial *positive* association, statistic threshold $p=0.029<0.05$, with $r = 0.582$. The coefficient of determination $r^2= 0.339$ shows a strong correlation between the two parameters.

III. ***Quality of movement –*** besides the *level of spasticity*, *the functional evaluation of the affected upper limb – time of task execution and the functional capacity*, it correlates significantly with the following parameters*:*

1. Amount of usage, very strong *positive* association, statistic threshold $p<0.001<0.05$, with $r = 0.903$. The coefficient of determination $r^2= 0.903$ shows a very strong correlation between the two parameters.
2. Life quality, very strong *positive* association, statistic threshold $p=0.001<0.05$, with $r = 0.776$. The coefficient of determination $r^2= 0.602$ shows a very strong correlation between the two parameters.

IV. ***Amount of usage -*** besides the *spasticity level*, *the functional evaluation of the affected upper limb – time of task execution, the functional capacity and the quality of movement*, it is in a strong *positive* association with the life quality parameter. The statistic threshold is $p=0.002<0.05$, for $r=0.753$. The coefficient of determination $r^2= 0.567$ shows a very strong correlation between the two parameters.

V. The Spearman correlation between the test results (parameters) and the nonmodifiable risk factors is not statistically relevant with the patients' age and sex, statistic threshold $p > 0.05$.

The previous stroke risk factor is strongly and positively associated with the movement quality and life quality parameters, and strongly but negatively with the level of spasticity. Stroke Debut risk factor is strongly and positivery associated with the level of spasticity and the functional evaluation of the affected upper limb – time of task execution. Also, Stroke Debut is strongly and negatively associated with movement quality and amount of usage parameters.

Modifiable risk factors

According to Spearman, the tests results correlate significantly with the modifiable risk factors, as follows:

1. The level of spasticity significantly, strongly and negatively correlates with smoking; there is a very strong positive association with diabetes, as shown in table 12.70 (in the thesis) for the statistic threshold p and the coefficient of correlation ρ and in table 12.71 (in the thesis) for the coefficient of determination $\rho^{2.}$
2. The evaluation of the functional capacity of the affected upper limb significantly, strongly and negatively associates with diabetes and HTA

according to the data in table 12.70 for the statistic threshold p and the coefficient of correlation ρ and in table 12.71 for the coefficient of determination ρ^2.

3. The quality of movement significantly, very strongly and negatively correlates with diabetes. The values for the statistic threshold p and the coefficient of correlation ρ can be found in table 12.70 and for the coefficient of determination ρ^2 in table 12.71.
4. The amount of usage significantly, very strongly and negatively associates with diabetes. The values for the statistic threshold p and the coefficient of correlation ρ can be found in table 12.70 and for the coefficient of determination ρ^2 in table 12.71.

The conclusions regard both the theoretical basis of this research, as well as its practical outcomes.

Thus, stroke represents a national priority in terms of health because it is the second most prevalent death cause for women, and third for men, but also the main cause of nontraumatic motor disability in adults, which negatively impacts on the care, invalidity and pension expenditures, as well as on life quality.

Post stroke reeducation is based on two very different, almost opposite methodological approaches, classified as classical and modern, to which the Parfetti concept can be added. The classical methods employ motor sensory stimulation exercises, patogenic or compensatory mechanisms for the injuries of the nervous system. Some of them have been updated without abandoning the specific points of reeducation but transforming them intro *concepts* (Bobath, Kabat, presented in the thesis). The Perfetti concept unites the elements of the classical concepts based on neuromotor theories with the principles of modern cognitive theories, based on stimulating brain plasticity. Parfetti argues that "movement should not be separated by the experience that created it."

Coercive restraint therapy is one of the new methods explored in this research, based on the principle of *learning to NOT use* the healthy upper limb in an effort to constrain the patient to use the stroke affected upper limb. Basically, the objective of the method is to reverse the learning of non-utilisation and to facilitate the utilisation dependent cortical reorganisation in order to reduce impairments and increase life quality. New ways of recovery after the death of the neurons in the brain area affected by stroke are also being envisioned. Unconditioned by multiplying surgery or pharmacology advances, recovery/reeducation programmes will always play an essential role in consolidating the results of this kind of therapy. Physiotherapists will undoubtely continue to have a central role in stimulating the potential neuromotor and psychosocial energies of stroke affected patients. In fact,

patients also regard physiotherapists as the holders of the remedies necessary for physical, mental and social recovery.

This research allowed us to draw a series of conclusions regarding the modifiable and nonmodifiable risk factors responsible in strokes, as well as their monitoring which is able to offer a prognosis of the patients' evolution. Establishing the age interval most affected by ageing, determining the gender ratio in terms of stroke risk and its existence in previous cases, determining the incidence of various cadriovascular afflictions, smoking etc.

The research undertaken, the data that was obtained, processed and interpreted led to the confirmation of our hypotheses.