SUMMARY

I. Importance of the problem, motivation of the paper .............................................. 2
II. Hypotheses of the research, goals and aim of the paper ...................................... 2
   2.1. Hypotheses of the research .............................................................................. 2
   2.2. Objectives and goal of paper ............................................................................ 2
III. Material and methods .............................................................................................. 3
   3.1. Presenting the group of patients ........................................................................ 3
   3.2. Methods of research ......................................................................................... 4
      3.2.1. Evaluation methods ..................................................................................... 4
         3.2.1.1. The clinical evaluation ............................................................................. 4
         3.2.1.2. Functional evaluation ............................................................................ 4
         3.2.1.3. The biomechanical evaluation ............................................................... 4
         3.2.1.4. Paraclinical evaluation .......................................................................... 5
      3.2.2. Statistical methods ........................................................................................ 5
   3.3. The functional rehabilitation programme applied ............................................... 5
      3.3.1. Aims of the recovery .................................................................................... 5
      3.3.2. Means of the recovery ................................................................................ 6
IV. Results and discussions ............................................................................................. 6
   4.1. Results of clinical-functional evaluations .......................................................... 6
      4.1.1. Groups by age and gender ............................................................................ 6
      4.1.2. Clinical features .......................................................................................... 7
      4.1.3. Neurological variables ................................................................................ 7
      4.1.4. Functional variables .................................................................................... 8
      4.1.5. Statistical assessment of the results of clinical-functional evaluations .......... 8
   4.2. The results of the gait biomechanical evaluation ............................................... 9
      4.2.1. The results of the biomechanical evaluations depending on the localisation of the motor deficit .................................................. 9
      4.2.2. Statistical assessment of the results of biomechanical evaluations .......... 11
Conclusions ...................................................................................................................... 12
Curriculum vitae ............................................................................................................. 13

KEY WORDS: stroke, complex assessment, rehabilitation treatment.
I. IMPORTANCE OF THE PROBLEM, MOTIVATION OF THE PAPER

Cerebrovascular accidents have an important social impact and involve the existence of big costs related to the recovery process. There is no algorithm for complexly evaluating this category of patients, which would allow the recoverer to prepare a rehabilitation programme, properly and efficiently oriented.

II. HYPOTHESES OF THE RESEARCH, GOALS AND AIM OF THE PAPER

2.1. HYPOTHESES OF THE RESEARCH

The premises for establishing this research were:

✓ Increased incidence of cerebrovascular accidents also in progressively younger ages.
✓ Family, socio-economic and medical impact of failures occurred after stroke.
✓ Frequently associating the spasticity in patients with hemiparesis after stroke and influence onto their evolution and functional prognostic.
✓ Proving the beneficial effects of early initiation of gait recovery programmes in case of patients with spastic hemiparesis.
✓ The need to make the results of post stroke gait recovery physical-kinetic programmes objective.
✓ Approaching the gait recovery process from a biomechanical point of view.
✓ Evidence-based practice as coordinating principle of the progress and medical attitudes in recent years and in future.
✓ Improving patients’ quality of life as fundamental principle of medical application.

2.2. OBJECTIVES AND GOAL OF PAPER

In our scientific approach, we propose the following objectives:

▪ The complex clinical-functional assessment according to the clinical scales and biomechanical evaluations.
▪ Preparing a functional rehabilitation programme based on the results of the clinical-functional evaluations.
▪ Implementing the complex rehabilitation programme, early (within the first 3 months as of the occurrence of the cerebrovascular accident) for those patients with spastic hemiparesis and monitoring this programme compared with the introduction of the same programme at an interval of more than 3 months.
▪ Assessing the efficiency of the drug and physical-kinetic treatment by adapting the rehabilitation methodology according to the results obtained.
▪ Achieving the independence in locomotion or daily activities, resuming the professional activity with the aim to improve the patient’s quality of life.
III. MATERIAL AND METHODS

The research was performed in the Clinic for Neurological Recovery of the Clinical Neuropsychiatry Hospital of Craiova in between 2006 and 2010, covering 4 stages of clinical-functional evaluation: initial (upon internment), intermediary (3 weeks, 3 months, 6 months) and final (in 1 year). Intermediary evaluations were needed for monitoring the recovery programme. The biomechanical assessment was done at an interval of 6 months and at the end of the study.

3.1. PRESENTING THE GROUP OF PATIENTS

The study was initiated on a number of 100 patients hospitalised and diagnosed with ischemic CVA, during the acute period of the disease in the Neurology Clinic and were included into the recovery programme in the Neurological Recovery Clinic of the Clinical Neuropsychiatry Hospital of Craiova. The patients were divided into two groups depending on the length of period of the cerebrovascular accident:

Group A consisted in 50 patients with ischemic C.V.A. who started the recovery programme during the first 3 months after the disease began. Group B consisted in 50 patients who were included into the recovery programme after 3 months after the disease began.

The composition of the groups was based on common criteria of inclusion, respectively of exclusion:

Inclusion criteria:
2. Disability present for at least 2 functional levels.
3. Preservation of the cognitive functions and communication skills in order to enable a good collaboration and active participation to the recovery programme.
4. Endurance to physical effort.
5. The first internment into a recovery section.

Exclusion criteria:
1. Hemorrhagic CVA
2. Multiple CVA
3. Presence of muscular atrophies due to other neurological diseases related to a CVA.
5. Absence of family’s approval.
3.2. METHODS OF RESEARCH

3.2.1. Evaluation methods

To this effect, we have used complex methods for assessing the functional lack and gait rehabilitation potential, by starting from objective results.

3.2.1.1. The clinical evaluation took into account the patient’s clinical profile according to which the possibility of integrating it into a gait rehabilitation programme was assessed.

3.2.1.2. Functional evaluation

- The functional indexes used in assessing the functional deficit were: Tinetti scale, Berg scale, Functional Ambulation Categories (F.A.C.), Fugl - Meyer Scale, Barthel Index, Functional Independence Degree (FID) Scale, Functional Independence Measure (F.I.M); Mini Mental State Examination (M.M.S.E.), Quality of Life Indicator (QOL) Family support, it was noted thusly: weak, average, intense.

3.2.1.3. The biomechanical evaluation represented a quantitative assessment of some parameters enabling the quantification of gait which depends on the functional performances of the lower limb.

In this study, we used a platform for distributing the force and plantar pressure Footscan Scientific Version, RSSCAN International, Olen, Belgium, able to make measurements with a frequency of 500Hz in 2D and record the complete action of both plants. In the study performed, we synthesised the 8 stages of gait in 3 stages, recta: ground attack stage; semi-supporting stage and propulsion stage. Recordings are done at the level of 10 anatomic areas of the plant, but in our studio, we used only 4 areas, which we deemed as significant: heel-lateral zone (HL - heel lateral); heel-medial zone (HM - heel medial); middle area of the plant (MF - midfoot); area of the toes II-V.

- Assessment of the studied parameters

  The following pressure parameters have been studied, such as force and balance:

  - Maximum pressure recorded in the studied area - \( \text{Max P} \) (N/cm\(^2\))
  - Maximum force registered for the studied area - \( \text{MaxF} \) (N)
  - Impulse- \( I \) (Ns/cm) – represents the total loading of the assessed area
  - Load rate in the assessed area – load rate- \( \text{LR} \) (N/cm.s)
  - Contact area – \( \text{CA} \) (cm\(^2\))
  - Contact ratio (%) of the active surface in the supporting phase - \( \%C \)
  - Distribution of pressure while walking
  - Distribution of the pressure centre - \( \text{CP} \)
- The angle of the foot expresses the deviation from the walking direction and is quantified through negative values stating the endorotation or positive values stating the exorotation.
- Subtalar angle - formed between the axes of the talus and calcaneus.
- The balance diagrams (rotation of the hill, balance of the foot, loading in the metatarsal area also bringing information about the stability of the foot when walking).
- Foot type assessed depending on the value of the plantar arch index (Al-arch index).

3.2.1.4. Paraclinical evaluation

3.2.2. Statistical methods

Statistical evaluation has included methods for assessing the clinical-functional and biomechanical parameters resulted from assessing the gait. Data statistical processing, as well as the graphical representations were done by using packages of general mathematical software (Microsoft Excel) or specifically statistical (academic package, Minitab 15 or the package distributed by OMS, EPI 2000). The calculations and statistical assessments in the Microsoft Excel software were done by using the predefined functions, the module Data Analysis, as well as XLSTAT and WINSTAT.

The statistical indicators used: arithmetic mean, division, dispersion, standard deviation, variation coefficient, median (quartile 2), quartiles 1, 2 and 3 (Q₁, Q₂ and Q₃).

For the assessment of the measurements where the values of the samples experimentally registered are distributed to, the Probability plot instrument was used in the Minitab 15 software (the Anderson-Darling Test and Pearson correlation coefficient).

Comparison of the means was done as applicable, with: Student’s t test, the test of the ANOVA variance analysis, the non-parametric Wilcoxon test.

3.3. THE FUNCTIONAL REHABILITATION PROGRAMME APPLIED

3.3.1. AIMS OF THE RECOVERY

- Controlling spasticity
- Controlling pain
- Controlling vicious postures
- Restoring force and muscular resistance
- Restoring and maintaining mobility
- Restoring the motor control (reproducing certain normal movement schemes, establishing symmetry in movement and posture)
- Restoring coordination and movement skills
- Restoring the balance
➢ Training the gait
➢ Restoring the sensitivity
➢ Gaining the maximum possible level of functional independence
➢ Social-family reintegration
➢ Professional reorientation (eventually)

3.3.2. MEANS OF THE RECOVERY: Drug therapy; Physical therapy; Kinetic therapy

IV. RESULTS AND DISCUSSIONS

4.1. RESULTS OF CLINICAL-FUNCTIONAL EVALUATIONS

4.1.1. Groups by age and gender

Patients included in the study ranged between the ages of 30-79, observing a predominance of patients ranging from 30-60 years of age for group A (22 patients) compared to group B where the predominance consisted in patients with ages over 60 (31 patients) (Diagrams 1, 2).

![Diagram 1 Distribution of Group A by age](image1)

![Diagram 2 Distribution of Group B by age](image2)

The distribution by gender highlights the predominance of male patients (58% in group A and 56% in group B), within the two groups being confirmed the current statistical data (Diagrams 3, 4).

![Diagram 3 Distribution of Group A by gender](image3)

![Diagram 4 Distribution of Group B by gender](image4)
4.1.2. Clinical features

By comparing the frequency of the complications during the study, it is noted that for patients in group A, the complications of the acute phase of the disease where more frequent (urinary tract infection 12%, bedsores 8%, cardiovascular complications 10%) compared to patients of group B, where a higher frequency of psychiatric disorders was noted of 28%.

Associated diseases

The patients in both groups indicate in significant ratios: cardiovascular diseases, hyperlipidemia, diabetes mellitus, obesity (Diagrams 5, 6).

4.1.3. Neurological variables

In terms of locating the motor deficit, we note there is the same localisation of the motor deficit for both groups (group A 52% on the left, 48% on the right; group B 51% on the left, 49% on the right) (Diagrams 7, 8).

Type of motor deficit

The assessment of the other neurological variables indicates the existence in group A of a number of 21 patients (42%), where the recovery programme was initiated in one month after the occurrence of the cerebrovascular accident, a paralytic predominant motor deficit (40 patients, 80%), cu with sensitivity disorders present in 30 patients (60%), sphincter control absent in 15 patients (30%).

By comparing the same neurological variables to those of group B, it is noted that a lower number of paralytic patients (30 patients, 60%), with sensitivity disorders, 20 patients
(40%) and the absence of the sphincter control is encountered only in 7 patients (7%).

4.1.4. Functional variables

The clinical-functional evaluation has showed a favourable evolution of the subjects in group A, who initiated the recovery programme during the first three months since the occurrence of the ischemic attack. By comparing the values of scores of the evaluation scales in 1 year compared to the initial moment, their improvement is clear in the patients of group A compared to those of group B where the recovery programme was initiated only after 3 since the ischemic attack was triggered (Diagram 9).

4.1.5. Statistical assessment of the results of clinical-functional evaluations

The Student test highlights a significant difference of the values of the scores between the moment of initiating the recovery treatment and evaluating the patients in 1 year compared for the 2 groups of study, group A whose patients started the recovery in the first 3 months, presenting statistically better significant values than for patients in group B, who were included into the recovery programme after 3 months since the occurrence of the cerebrovascular accident (Table 1).

**TABLE 1 STUDENT'S T TEST for group A and B**

<table>
<thead>
<tr>
<th>Task</th>
<th>Test 1</th>
<th>Test 2</th>
<th>Test 3</th>
<th>Test 4</th>
<th>Test 5</th>
<th>Statistical significance</th>
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<tr>
<td></td>
<td>t</td>
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<td>t</td>
<td>p</td>
<td>t</td>
<td>p</td>
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<td>1</td>
<td>-5</td>
<td>&lt;0.001</td>
<td>-1.91</td>
<td>0.032</td>
<td>3.32</td>
<td>0.022</td>
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<td>2</td>
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<td>&lt;0.001</td>
<td>-4.23</td>
<td>&lt;0.001</td>
<td>0.53</td>
<td>0.598</td>
</tr>
<tr>
<td>3</td>
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<td>&lt;0.001</td>
<td>-2.46</td>
<td>0.016</td>
<td>2.81</td>
<td>0.006</td>
</tr>
<tr>
<td>4</td>
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<td>0.88</td>
<td>0.38</td>
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<td>&lt;0.001</td>
</tr>
<tr>
<td>5</td>
<td>-2.13</td>
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<td>-0.35</td>
<td>0.726</td>
<td>2.59</td>
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<td>6</td>
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<td>7</td>
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<tr>
<td>8</td>
<td>-4.91</td>
<td>&lt;0.001</td>
<td>0.22</td>
<td>0.825</td>
<td>5.14</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>9</td>
<td>-3.65</td>
<td>&lt;0.001</td>
<td>0.07</td>
<td>0.941</td>
<td>4.05</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>10</td>
<td>-0.74</td>
<td>0.462</td>
<td>1.93</td>
<td>0.056</td>
<td>3.96</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>11</td>
<td>-4.5</td>
<td>&lt;0.001</td>
<td>0.18</td>
<td>0.795</td>
<td>4.80</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>12</td>
<td>0.7</td>
<td>0.483</td>
<td>0.87</td>
<td>0.386</td>
<td>0.93</td>
<td>0.356</td>
</tr>
</tbody>
</table>

Tinetti balance (1), Berg (2), Tinetti gait (3), FAC (4), Fugl-Meyer (M.S.=5; M.I.=6; S.A. = 7), Barthel (8), G.I.F. (9), F.I.M. (10), QOL (11), M.M.S. (12).
4.2. THE RESULTS OF THE GAIT BIOMECHANICAL EVALUATION

The gait biomechanical evaluation was done within some initial assessments in 6 months and final ones in 1 year since the occurrence of the ischemic attack.

4.2.1. The results of the biomechanical evaluations depending on the localisation of the motor deficit

Regarding the pressure and force parameters, we have noticed an increase of 54% of the values for the left paralysed lower limb, compared to the initial values existing when starting the rehabilitation programme, and at the level of the paralysed right lower limb, a drop of the absolute values of the force and pressure parameters is recorded, a significant drop of approximately 52%, while the contact surface remains at the same values.

The foot balance analyzed during the three phases of the gait cycle, taken for the study, indicated to us the existence of an endorotation of the hill of the paralysed left lower limb, with absolute average values of -10 and supine in the three studied phases, values that are noticed to drop during the 2\textsuperscript{nd} and 3\textsuperscript{rd} phases, at the final evaluation. Compensatory at the level of the non-paralysed lower right limb, we note an increase of the pronation in all three phases (Diagram 10).

For the cases of right hemiparesis, the initial moment of evaluation indicates the presence of an endorotation of the heel and supination during the three phases of the gait cycle, already mentioned, fact confirmed by the negative values of kinematic parameters meant to evaluate the foot balance. These values become positive at the end of the evaluation, during the 2\textsuperscript{nd} and 3\textsuperscript{rd} phases, which proves the existence of a correlation meant to develop the pronation pattern. Considering the non-paretic lower limb, positive values of foot balance parameters are recorded, implementing the pronation movement during all three phases of the gait cycle. The analysis of the curves, reflecting the evolution of the foot balance during the three phases of walking, displays ways of walking of opposite directions and the paretic lower limb
loading is achieved at the level of the tarsometatarsal, fifth metatarsal (V) and hallux area (Diagram 11).

![Diagram 11 Right/left foot balance (right hemiparesis)](image)

The distribution of the pressure centre in the case of patients with left hemiparesis indicates the existence of an uneven distribution at the initial moment of the evaluation, with a favourable evolution in the rehabilitation programme, focused on the training the balance, observing an improvement of this distribution upon the final evaluation.

For the right hemiparesis, we could refer to a relatively even distribution, even on the initial moment of the evaluation, probably explained by the right motor dominance.

Foot type - arch index (AI). In the case of subjects left hemiparesis, AI indicated 40%, which involved a side plantar correction leading, thus, to an AI of 38%, imposing a diminution of the degree of plantar correction. However, at the moment of final evaluation, a bilateral correction of the heel was needed in order to achieve a 20° elevation of the heel.

For the subjects with right hemiparesis, one may notice a reduced need for lowering the plantar arch, therefore, a reduced aspect of low arched foot, AI being 29%, meeting the normal limit, which is proved by the subject's behavior during the gait cycle, more precisely, by the ankle foot joint system mobility. This approach, considering the arch index, marks the fact that subjects with right hemiparesis do not need complex correction and manifest a higher degree of functional freedom. Contrary to the expectations, all subjects evaluated manifest a bipedal stability and do not evince any at the level of metatarsal joints.
4.2.2. Statistical assessment of the results of biomechanical evaluations

<table>
<thead>
<tr>
<th></th>
<th>Values p</th>
<th>Kruskal-Wallis Test 1/test 2</th>
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</thead>
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<tr>
<td></td>
<td>% Contact</td>
<td>Fmax</td>
</tr>
<tr>
<td>Heel lateral</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lot I</td>
<td>0</td>
<td>0.019</td>
</tr>
<tr>
<td>Lot II</td>
<td>0.114</td>
<td>0.28</td>
</tr>
<tr>
<td>Heel medial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lot I</td>
<td>0.029</td>
<td>0.049</td>
</tr>
<tr>
<td>Lot II</td>
<td>0.455</td>
<td>0.741</td>
</tr>
<tr>
<td>Midfoot</td>
<td></td>
<td></td>
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<tr>
<td>Lot I</td>
<td>0.002</td>
<td>0.005</td>
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<tr>
<td>Lot II</td>
<td>0.58</td>
<td>0.594</td>
</tr>
<tr>
<td>Meta 1</td>
<td></td>
<td></td>
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<tr>
<td>Lot I</td>
<td>0.093</td>
<td>0.084</td>
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<tr>
<td>Lot II</td>
<td>0.786</td>
<td>0.774</td>
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<td>Meta 5</td>
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<tr>
<td>Lot I</td>
<td>0.001</td>
<td>0.011</td>
</tr>
<tr>
<td>Lot II</td>
<td>0.004</td>
<td>0.073</td>
</tr>
</tbody>
</table>

Statistical interpretation:

1. The biomechanical parameters recorded on Group I shows increases of over 100%, with one exception, arguing the favourable evolution of their values for patients for whom the recovery programme was initiated during the first 3 months since the occurrence of the ischemic attack.

2. The parameters recorded for Group II systematically show percentage values of the increase, lower than in Group I, the recovery started after the first 3 months being less efficient.

3. In case of Group II, decreases of the analysed parameters are recorded for 5 values, the Meta 1 phase being the richest one (4 parameters).

4. Although the values of the recorded parameters are generally also increased for group II, the differences are not statistically significant.

5. By analysing the table with values p when statistically comparing for the two groups by means of the studied parameters, we note systematically significant values (<0.05) for Group I and more rarely for Group II.
CONCLUSIONS

By responding to the hypothesises of the research and objectives of the study, we may enunciate the following conclusions:

1. *Early initiation* of the post-CVA recovery programmes is related to functional and prognostic scores that are higher to late recovery (an aspect highlighted by the evolution of the scores of the evaluation scales).

2. The assessment of the functional scores indicate however that not initiating the recovery programme within the first 3 months since the occurrence of the disease obstructs a functional recovery of the lower limb, which would ensure resuming the gait.

3. By means of the results of the clinical-functional assessments, this study proves that *early initiation* of recovery and adaptation to the kinetic physical programme according to the biomechanical parameters obtained ensures the *statistically significant* improvement of all scores of the evaluation scales.

4. The analysis of the results of these evaluations highlights that the recovering potential is higher for those patients with *right hemiparesis*.

5. The biochemical evaluations have proved the existence of some *major differences between the paralysed and non-paralysed segment*.

6. The analysis of the gait patterns has indicated that for *group I*, the *ground reaction force* has progressively increasing values while running the plant on the ground, close to the values of the healthy subjects and in concordance with the body weight.

7. The biomechanical analysis performed led us to find out there is an *incomplete separation* of the foot off the ground, due to the *stereotype supraspinal control*.

8. *Late initiation* of the recovery programme determines the *loss of the cerebral engrams*.

9. Till now, there are not biomechanical evaluations of the kind shown here, which would make objective the importance of the *connection between the ground reaction force and gait phases for the hemiplegic patient*.

10. The patient’s “*profile*” with a maximal response indicates us a patient in the sixth decade of life, without diabetes mellitus, with right hemiparesis, whom had small and medium clinical-functional scores upon joining the study.

11. Although specialised literature does not bring clear data regarding the moment of initiating the therapy of gait recovery from hemiplegia after CVA based on a *clinical-functional and biomechanical complex evaluation*, I deem that early establishment (during the first 3 months) of the recovery treatment leads to improving the patients' quality of life.
CURRICULUM VITAE

1. Name: Păun (Iova)
2. Forename: Elvira
3. Date and place of birth: 15.10.1956, Craiova
4. Citizenship: roumanian
5. Marital status: married
6. Education:

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<tr>
<th>Institution</th>
<th>General School number 2, Craiova</th>
<th>High School „Nicolae Balcescu“</th>
<th>Faculty of Medicine, University of Medicine and Pharmacy, Craiova</th>
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7. Professional experience:

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<td>Melinești Health Center</td>
<td>No. 3 Clinical Hospital</td>
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<td>Position</td>
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<td>Specialist Physician in Physical Medicine and Rehabilitation</td>
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<td></td>
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<td>Event Medical Director-2009</td>
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8. Scientific title:

Assistant Professor (2006) University of Craiova, Faculty of Physical Education and Sport, Department of Kinetotherapy.

Master Degree, University of Medicine and Pharmacy, Craiova "Management of Sanitary Units" (2010).

Assistant Professor preparing for a doctor’s degree in Medical Sciences within the study discipline Physical Medicine and Rehabilitation Faculty of Medicine, University of Medicine and Pharmacy, Craiova, Scientific Coordinator PhD Roxana Popescu (2005).
9. Actual place of work and function:
**Primary Care Physician**, *Neuropsychiatry Clinical Hospital Craiova, section: Neurological Rehabilitation.*

**Assistant Professor**, *University of Craiova, Faculty of Physical Education and Sport, Department of Kinetotherapy.* Didactic activity consists in teaching courses - Kinetotherapy in Orthopedic Traumatic Diseases, Prosthesis-Orthosis, and practical works in Neurological Disorders Kinetotherapy.

10. **Member of professional associations:**
Romanian Society of Physical Medicine and Rehabilitation
Romanian Society of Rheumatology

11. **Member in research projects:**
1. GRAND CNCSIS 2006-2008 COD 588 „Contributions to the study of applying physical resistance exercise in patients with spasticity after stroke”
2. IDEAS PROGRAMME CNCSIS 2008 "Algorithm for evaluation and rehabilitation of gait in hemiplegic patients"

12. **Foreign languages:** English, French