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Abstract of the doctoral thesis:

Strategies concerning the recovery of gait function in children with hemiparetic cerebral palsy, based on the computerized biomechanical analysis

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Introduction

The idea of this thesis originated from the necessity of applying an adequate assessment for this type of condition, which could be afterwards integrated in the recovery program. The assessment is meant to describe as much as possible the patient's condition, and the treatment is limited by the weak logistics in the specialized centers. In the literature, the studies concerning the one-time application of one therapy have shown there is no efficiency, while applying it in a scheme comprising several methods is efficient.

This type of condition, the spastic hemiparesis, is a purely pyramidal syndrome, representing 30% of the total number of cases of cerebral paralysis, very seldom discovered at birth, with satisfactory post-therapeutic results. In most cases, the patients succeed in gaining the autonomous gait, with the specific disorders caused by spasticity, the incorrect co-contraction of the antagonist muscles, the appearance of the clonus, of the synkinesis, the hyperactivity of reactions of recovery and rebalancing on the healthy part, the subsequent bone deformations, following spasticity. These gait abnormalities, if incorrectly managed, produce consequences hard to redress, with major negative effects on the physical activity, on independence, on the personality and the psych.

The independence given by the ability to move allows the interaction of the society, a good emotional evolution, and – why not? – career bust.

These are part of the arguments leading to the choice for this topic.

The bibliography comprises 32 works from the Romanian literature, 181 works from the foreign literature, 24 on-line bibliographical references.

The thesis is structured into three parts, each part meeting the objectives set out.

In the Introduction of the thesis, I have defined certain topic-related aspects, in which I have given the definitions as they are found in reference books.

Part I

In the first part, I critically approached the literature, in order to emphasize the necessity of conducting this research. I recalled certain theoretical aspects, already known, related to anatomy and biomechanics, to the pathology of the decease and what its clinical picture comprises, to the novelties in the field of the computerized biomechanical analysis of gait, in the bionic and manual recovery, to the status of the recovery system in Romania.

Part II

The second part includes the preliminary study, which started by determining the purpose, the hypothesis, the tasks, and the objectives, by setting out the inclusion and exclusion criteria, by completing the working documents.

The scope of the research is that of emphasizing the effects physiotherapy has, through its means, procedures and techniques on the spatial-temporal parameters of gait, and on the clinical evolution of the patient with hemiparetic cerebral palsy.

The research hypothesis is connected to the integration of computerized biomechanical analysis into the complex treatment of the child with hemiparetic cerebral palsy, in order to carry out efficient strategies of reeducating the gait function of these children.

The organization and the conduct of the research took place in the framework of the National Medical Center of Neuropsychomotor Recovery for Children "Dr. Nicolae Robănescu" [CNCRNC „Dr Nicolae Robănescu"], in the period 2014-2019, a center having the necessary logistics for carrying out this type of research.

In the preliminary research, 30 subjects were included, 13 girls and 17 boys, 12 with left spastic hemiparesis, 18 with right spastic hemiparesis, between the

ages of 4 and 9, who have acquired the gait with the condition-specific disorders. The spatial-temporal parameters were obtained by studying the ankle and the leg and their position in space, using the optoelectronic technology within the laboratory of the computerized biomechanical analysis of gait. The clinical evaluation was carried out in the laboratory of bionic and manual recovery, from where the most relevant scales have been selected for the data analysis and interpretation: the muscle strength, functional evaluation of gait(Functional Mobility Scale and Gillette Scale), for the muscle tone assessment (Modified Ashworth Scale), for assessing the selective motor control (Boyd Scale).

The reassessment was carried out after 6 months.

The preliminary data analysis reflects the major gap these children have compared to the normal, hence a first preliminary conclusion, that we cannot apply a standard treatment for every patient and that the treatment should be adapted to the patient's needs. If we do not intervene when the child has recovery possibilities (time, innocence, etc.), we won't be able to do anything later.

Part III

The research *per se* aims at perfecting the process of reeducating the gait abnormalities in patients with hemiparetic cerebral palsy, outlining a new hypothesis against the preliminary research, the one that carrying out an exact biomechanical assessment, one to include also the indications regarding the neuro-mio-kinetic structures of gait, determines the improvement in the quality of the recovery of gait in these children.

Taking responsibility for the success is not strictly the physiotherapist's, but one of the entire multidisciplinary team (doctor, physiotherapist, psychologist, ergotherapist, etc.), so that, by working as a team, the clinical evolution of the child with cerebral palsy can be improved.

Methods employed:

- Bibliographical research method;
- Observation;
- Conversational interviewing;
- Experimental method;
- Measurements and data recording (the goniometer, the centimeter, the pelvimeter, the weigher, the specific evaluation tests, the rating scales, the camera, the optoelectronic technology);

- Graphic and tabular method;
- Statistical-mathematic method.

The complex recovery treatment employed in the framework of this study took account of the principles of neuroplasticity, of the stages of motor learning, of the milestones of the neuropsychomotor development. Physiotherapy techniques and procedures were used (targeted at assisted active activities, at reciprocal activation-inhibition agonist-antagonist stimulation, at the production of isotonic-isometric contractions, of simulating day-to-day situations, at the balance training (by integrating oculomotor gymnastics)), along with bionic therapy.

The spatial-temporal parameters represent "the vital signs" of gait. In this study, the following spatial-temporal parameters are employed:

- *Stride Time (sec)*
- *Stance Time (sec)*
- *Swing Time(sec)*
- *Stance Phase (%)*
- *Swing Phase (%)*
- *Mean Velocity (m/sec)*
- *Mean Velocity (%height/sec)*
- *Cadence (steps/min)*
- *Stride Length (m)*
- *Stride Length (%Height)*
- *Step Length (m)*
- *Step Width (m)*

Data analysis and interpretation

The statistical study is structured into 3 sections (parameters obtained from the clinical evaluation, parameters obtained from the gait analysis report, and comparisons between the left hemiparesis and the right one regarding the success of the treatment). In these sections, the parameters are analyzed from the descriptive and inferential statistics' point of view:

1. Modified Ashworth Scale (MAS), for evaluating the spasticity on the muscles of the lower limb;
2. Boyd Scale, for evaluating the motor control;
3. The muscle strength on the muscles of the lower limb;

4. The functional evaluation (Functional Mobility Scale – FMS, and Gilette Scale);
5. The spatial-temporal parameters of gait, obtained from the report of the computerized biomechanical analysis of gait;
6. Comparative analyses regarding the effectiveness of the treatment on the affected parts.

From the boxplot analysis and from variable testing, one can observe that, 6 months after starting the treatment, the results are statistically significant ($p < 0,05$):

- The MAS score: on the gastrocnemii, the soleus and on the hamstrings, slight on the adductors;
- The muscle balance: on all muscles, but the most on the hamstrings, the tibialis anterior and on the triceps surae;
- From the functional point of view: FMS and Gillette;
- Boyd Scale.

The dependent sample t-test ("initial-final" comparison) was applied, and there were variations for *Stride Length(m)* on the left hemiparetic part, and for *Step Length (m)* and *Stride Length (m)* on the right hemiparetic part.

The one-sample t-test was applied, relative to a reference value, and there were variations for the majority of the spatial-temporal parameters, irrespective of the hemiparetic part.

However, due to the low number of samples, the estimators' confidence interval is greater, the strength of statistical tests is reduced, and thusly the discrepancies between the results obtained and the real situation could be incorrectly labelled as (in)significant.

The paired sample t-test for every pair of parameters was applied, and thusly the following were compared:

- the samples' means to a reference value, using one-mean t-test. A good evolution towards normal values was shown in the parameters *Stance Phase (%)* and *Stance Time (sec)* on the left hemiparetic part, and *Mean Velocity (%height/sec)* on the right hemiparetic part.
- The two samples considered as independent variables, using the independent-samples t-test, in which the result showed there are not significant differences between the means of the two groups.

The major limitation of this thesis consists in the small number of subjects. Continuing this study on a larger group of patients would allow for baseline data valid for the analysis of gait.

Conclusions

The computerized biomechanical analysis of gait does not elaborate treatment protocols specific for each individual, the final decision being dependent on the therapist's philosophy, reason and experience.

The responses resulting from correlating the clinical evaluation and the computerized biomechanical analysis of gait will guide the therapist in choosing the closest treatment strategy for meeting the needs.

From the boxplot analysis and from variable testing (descriptive statistics, correlations and the t-test), one can observe that, 6 months after starting the treatment, there is statistical significance leading to the conclusion that the treatment of spasticity, of muscle strength, of motor control, of gait from the functional point of view, has been correctly applied, thus confirming the second hypothesis of this research, the one that carrying out an exact biomechanical assessment determines the improvement in the quality of the recovery of walking in children with hemiparetic cerebral palsy.

In the case of the 12 spatial-temporal parameters, for the 12 patients diagnosed with left spastic hemiparesis and the 18 with left spastic hemiparesis, the values leading to the rejection of the null hypothesis were recorded for *Stride Length(m)* and for *Step Length (m)*, namely spatial parameters, and for those relative to the minimum value of the reference value, statistically significant values were recorded for the majority of the spatial-temporal parameters. These results confirm the first research hypothesis, which is connected to the integration of computerized biomechanical analysis into the complex treatment of the child with hemiparetic cerebral palsy.

The final conclusion is that walking in itself is a complex process, and, even if I succeeded in improving the muscle strength, the motor control, in reducing the spasticity, I cannot have a spectacular evolution on the spatial-temporal parameters in such a short time, and it is possible, over time, to have spectacular results on the temporal parameters also. As an insight, for a good evolution, an intense, constant recovery is necessary, one to be carried out over a much longer period of time.

In order to have these results, a team work was conducted (comprising doctors, medical staff in the laboratory of the computerized biomechanical analysis of the gait, medical staff in the laboratory of bionic and manual recovery, psychologists, ergotherapists).

Dissemination

All throughout the doctoral studies, I have tried to achieve my own advance, both in the scientific field, but especially in practical terms, therefore, I attended lifelong learning courses in the field of rehabilitation. Together with my colleagues, I held workshops within the framework of the Academic Sessions organized by the Centre in which I conduct my activity, for 3 consecutive years, I have held workshops on the kinesiological bandaging in the field of neuropediatrics, for students of "Carol Davila" University of Medicine and Pharmacy, at the Faculty of Midwifery and Nursing, I participated in the Congress of the University of Physical Education and Sport in Bucharest, I coauthored a research compendium, I published 6 articles in scientific reviews.