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SUMMARY OF THE PhD THESIS

**MUSCULAR AND POSTURAL ASSESSMENT OF PATIENTS WITH
PARKINSON'S DISEASE**

PhD supervisor

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SUMMARY

Keywords: Parkinson's disease, myotonometric measurement, muscle analysis, postural analysis, motor disability, treatment compliance, diversity of rehabilitation programs, individual physiotherapy, group physiotherapy.

INTRODUCTION

The main purpose of this Thesis is to present significant details of the particularities of functional assessments through measurement and analysis technology in the field of Parkinson's disease.

The complexity of Parkinson's disease represents a permanently challenging and equally fascinating field of neurology and medical rehabilitation.

The main components of my Thesis are represented by the measurement of muscle parameters with the help of MyotonPRO technology, through which I discovered important elements of the properties of the muscle structure.

The measurement technique by means of the MyotonPro device brings valuable elements in the evaluation and monitoring of muscle structures. It is a unique research tool that provides accurate data; it is reliable and easy to use.

The MyotonPro device has an important role in the clinical and objective evaluation of the effectiveness of drug treatment and it is also extremely valuable in the evaluation and monitoring of physiotherapy.

The myotonometer allows a better understanding of how muscle tone, elasticity, stiffness are related to health and physical condition. The potential of Myoton technology is identified in medical fields such as medical rehabilitation, sports medicine with important predictions in the sphere of neurological, neuromuscular disorders and can have an important contribution in the detection of musculoskeletal disorders, it also has a prophylactic role because it can identify early muscle and ligament abnormalities thus, following the interpretation, appropriate decisions can be made in establishing the preventive therapeutic strategy.

MyotonPro technology describes the tissue in five aspects through different characteristics. Specific parameters of the device are represented by the tension state of the muscle tone (intrinsic tension at the cellular level), by „Oscillation Frequency” [Hz]. Higher than normal muscle tone disrupts the blood supply conditions of the muscle and increased tone is frequently associated with: muscle pain, fatigue, decreased physical performance, overstretch and delayed muscle recovery.

The biomechanical properties are analysed with the help of „*Dynamic Stiffness*” [N/m], dynamic stiffness is represented by the ability of a muscle to resist a force that deforms it.

Stiff muscles need more effort to be able to stretch, most of the time it is done incompletely producing asymmetry between body parts that can disrupt the functionality of the movement. Elasticity represents the ability of a muscle to restore its shape between two contractions and it is represented by „Logarithmic Decrement” but also the viscoelastic property through „*Mechanical Stress Relaxation Time*” [ms] and „*Ratio of Relaxation and Deformation Time*”.

All these elements are extremely important in the field of medical rehabilitation for the evaluation and monitoring of a patient with Parkinson's disease because in the recovery process the main objective is muscle, joint and general functionality.

In order to build a personalized recovery plan with notable results, I believe that I get the necessary information through the data provided by this device.

In addition to analysing the muscle changes in Parkinson's disease, an equally important element is represented by the postural changes that occur involuntarily in the advanced stages of the disease, we considered relevant the analysis of postures and body alignment with the help of the GaitON software. This analysis consists in determining the alignment of the spine, pelvis and lower limbs by analysing the axes following the import of images made with the help of markers at the level of the analysis areas.

All the measurements and programs proposed in the thesis bring important elements for building and adapting physiotherapy in a careful and personalized manner to each patient.

In order to have a clear view on the adaptability of patients and how they perceive both the importance and the role of medical recovery, I chose to do a quantitative analysis of patients' compliance with the diversity of medical rehabilitation programs, analyzing also the dynamic evolution of the proposed objectives.

All these means and tools used have brought an important contribution to the evolution of scientific research from the perspective of means of evaluation and monitoring in the evolution of Parkinson's disease.

Due to my professional activity that started 8 years ago and up to present at the Social Integration/Reintegration Day centre for people in difficulty within the Directorate of Social Assistance of the Municipality of Timisoara, which is specific to rehabilitation in a multidisciplinary context in the sphere neuropsychiatry, in this case Parkinson's disease, I could closely notice general and particular aspects of the disease, something that impressed me and developed my desire to study in depth the complexity of the disease and at the same time the therapeutic approach.

GENERAL PART

The general part of the thesis includes Chapter I structured in 10 sub-chapters that address general aspects and particularities of the Parkinson's diseases.

You can also find elements of the symptomatology, the manifestations and the evolution of the disease alongside the description of the disability induced by the disease and the classification into the degree of disability according to the stage of evolution and the way the symptoms manifest. The quality of life and the description of the diversity of rehabilitation programs applied in the studies described in the special part make up a set of possibilities by which it is desired to increase the quality of life of patients with Parkinson's disease.

History of Parkinson's Disease

James Parkinson and the Evolution of the Shaking Palsy

James Parkinson was born on 11 April 1755. James Parkinson studied at the London Hospital Medical College, qualified as a surgeon in 1784 at the age of 29, then joined his father in the campaign called *Parkinson and Son* to care for the sick people in the parish of St. Leonards of Shoreditch; later on for 30 years they have participated in the care and treatment of patients in a *Private Psychiatric Home*, all these activities of the Parkinson family have spread over a period of 80 years summing up 4 generations.

At the age of 62, in 1817, he first described Parkinson's Disease in the publication *An Essay on the Shaking Palsy*. This complex publication contained five chapters and 66 pages on the subject of this disease which he called at the time *Shaking Paralysis*.

All the description of the disease and the symptomatology was built on the long study of a group of 6 patients whom he met by chance on the street and which aroused in him an imperative desire to identify the nature of the symptoms and manifestations of the disease. James Parkinson describes the symptoms with exemplary accuracy considering the small number of cases studied.

It is worth noting that the aspects described by James Parkinson following the detailed analysis bring us, 200 years later, an extremely eloquent retrospective regarding the nature of the disease.

19th century - James Parkinson and contemporaries - from shaking palsy or shaking paralysis to Parkinson's disease

In 1861, the French neurologist Jean-Martin Charcot wrote that: Shaking paralysis is definitely a very little-known disease in the 45 years since its first description, also in that period the first publications written by Charcot and his interest in shaking paralysis began.

In 1865, Sanders proposed changing the name of the disease in several variants, including Parkinson's Disease, and in 1888, Charcot determined that the disease would take the name of its discoverer, James Parkinson.

Parkinson's disease: motor symptoms

The symptoms of the disease vary, they usually appear slowly and manifest themselves progressively in the course of the disease, they can be different even in the same person with an atypical manifestation from one day to another or during a day depending on the time.

Motor symptoms - the manifestation of the disease itself

In order to obtain a correct diagnosis, the element of identification and clinical definition of this pathology is represented by the motor symptoms - parkinsonism. Corresponding to the clinical diagnosis of a neuro-pathological nature, the loss of pigmented dopaminergic neurons in the proportion of 60-70% of the brain stem, especially the substantia nigra (SN) is identified along with the presence of Lewy bodies.

Replacement therapy and motor complications

The introduction of levodopa therapy has brought significant improvements in terms of quality of life and has increased life expectancy of patients with Parkinson's disease. With the help of the therapies, the symptomatology was successfully controlled when the treatment was adapted to the evolution of the disease. Over time, there have been changes in the effectiveness of the therapy and motor symptoms appeared against the background of dystonic - dyskinetic treatment doses, called motor fluctuations, usually present in the advanced stages of the disease.

Cognitive impairment in Parkinson's disease - the role of dopamine in cognitive dysfunction

In Parkinson's disease, cognitive deficit occurs in the absence of dementia. Mild cognitive deficits are identified in the early stages of Parkinson's disease in 15%-20% of untreated novo cases. Cognitive dysfunction can range from individual cognitive deficits to major cognitive impairments to dementia.

In Parkinson's disease, attention deficits of the executive function, visuospatial skills, memory deficit, poor verbal fluency can occur in the absence of dementia.

Dopamine also plays an important role in the processing of cognitive information and inadequate dopaminergic transmission or its deficiency alters the ability to process simultaneous cognitive tasks of a visual, auditory or reaction time nature.

Disease-induced disability

According to WHO globally, more than one billion people have a form of disability, of which 200 million have physical disability with a significant reduction in functionality.

Neurological disorders are the main source of physical disability worldwide, Parkinson's disease has had the fastest growth in the last 26 years.

In 2020, there were an estimated 9.4 million people living with Parkinson's disease. 6 million more than the cases reported in 2016, this number of patients comes from countries such as the US, Japan, France Italy, UK, Spain

In Romania in 2016, the Romanian Antiparkinson Association shows that there are 70.000 patients with Parkinson's disease on record.

The evolution of Parkinson's disease and the classification by degree of disability in the last 7 years in Timis county shows that the largest share of patients is identified with the degree of severe disability, this aspect reflects the progressive negative evolution of the disease but also the socio-psycho-social impact for the patient, next of kin and society.

In the absence of scientific education and moral principles that put health first, families and even communities have stereotypical reactions towards people with chronic disease status. Marginalizing them, keeping the "secret" of the diagnosis, isolating and even abandoning them (often camouflaged under the pretext of "care" and ensuring the comfort of the sick person), these are the behaviours that dominate in Romanian society today, at the expense of supporting an attitude of "fighting" against the disease, to combat its progress through supportive therapies, through psychological assistance, socialization and community solidarity - indispensable elements for maintaining an optimistic perspective and a state of well-being that affects the whole society.

Classification of symptoms according to the degrees of disability

According to the provisions of the Ministry of Labour, Social Protection and the Elderly and the Ministry of Health by order no. 672/1992/2017 which classifies people according to the medico-psychosocial criteria and establishes the classification in the degree of disability. The degrees of disability are established according to the way the disease manifests and following the neurological evaluation and paraclinical and imaging examination together with tools such as the Barthel index, ADL, I-ADL, UPDRS and staging according to Hoehn and Yahr.

Quality of life in Parkinson's disease

The quality of life represents the well-being and in the case of Parkinson's disease it can be summed up in acceptance, management of the disease by identifying non-motor symptoms, planning activities, managing emotions and creating a strategy according to the evolution of the disease.

Medical rehabilitation treatment in Parkinson's disease

Physiotherapy in Parkinson's disease plays an extremely important role for improving the quality of life, the approach of the specialists and the perception of the patients regarding the proposed programs is an indicator in the appropriate and effective construction of the therapy.

The diversity of physical therapy programs is based on a long study of how each type of program is for the benefit of the patient, the programs proposed in the studies found in the special part are the basis of the 7 programs described below.

- Posture correction;
- Exercises to increase mobility - Stretching;
- Increasing muscle strength and endurance;
- Hydrokinetotherapy in Parkinson's Disease;
- Group physical therapy (combined physical and cognitive activities);
- Program to improve stability, balance and gait;
- Development of the hand dexterity through ergotherapy.

SPECIAL PART

Personal contribution

Study 1. Determination of the muscle parameters of patients with Parkinson's disease before and after drug treatment using myotonometry

The main aim of the study is to identify changes in the state of muscle tone of patients with Parkinson's disease by analysing the mechanical properties of muscles before and after drug treatment compared to a group of healthy people.

The secondary objective of the research was to identify a possible correlation between the myotonometric parameters of the evaluated muscles and the characteristics of the patients.

Research material and methods

The study was carried out between September 15, 2022 - and January 15, 2023 within the Social Integration/Reintegration centre for people in difficulty in Timisoara, Romania.

The sample provided in the study consisted of two batches. The total sample consists of 91 people of which 45 are male and 46 are female.

We have chosen for testing four muscle groups important in the actions and activities of daily life of a patient with Parkinson's disease. (Muscles: pectoralis major, biceps brachii, biceps femoris, tibialis anterior).

The mentioned muscle was tested in two stages: The first determination was made before the administration of the drug treatment for the study group and the second determination one hour after its administration. The control group also had two tests an hour apart.

We wanted to follow to what extent the medicinal treatment is metabolized and acts, and also how quickly interventions can change the patient's functional status and what changes occur in the muscle structure.

The control group includes 42 healthy subjects, they do not have neurological conditions and fall into the same age, weight, height category as the study group.

The study group (patients with Parkinson's disease) consists of 49 patients diagnosed with Parkinson's disease who are undergoing specialized drug treatment.

More than half (53.1%) of the patients in the study group are in stage III of the disease, this stage shows a modified level of patients' functionality through the prism of bilateral symptomatic manifestations.

Results

Within the two determinations: before the administration of the medicinal treatment, as well as one hour after the administration of the medication. The group of patients reported a state of muscle tension, muscle stiffness and a significantly higher elasticity value, which means in the case of (Decrement) that the higher the value, the more the muscle cannot restore its shape relatively quickly between two contractions leading to fatigue and limitation of movement due to lack of elasticity. These elements alter the patient's degree of functionality in activities of daily living because the patient must make a considerably greater effort to perform an activity due to increased muscle tension and stiffness.

There are no statistically significant differences between pre-treatment and post-treatment testing in any of the five targeted parameters: Frequency $p=0.001$; Stiffness $p=0.02$, Decrease $p=0.001$. These aspects demonstrate the fact that an hour away from the administration of the drug treatment, the patient does not regain his functionality in carrying out daily activities and not only that.

Conclusions

Our research showed that the myotonometric parameters (stiffness state, dynamic stiffness and elasticity) from the pectoralis major, biceps brachii, biceps femoris and tibialis anterior showed that at the first assessment, carried out in the morning before the administration of the medication, they had significantly higher values compared to the control group consisting of healthy individuals of the same age category.

When attenuation is considered, the higher the value, the less the muscle can restore its normal shape between contractions. In these conditions, the state of fatigue and limitation of movement appear as a consequence of the lack of elasticity.

All these elements change the degree of functionality of the patient in carrying out daily activities, because the patient must make a considerable effort in carrying out an activity due to muscle tension and increased stiffness.

Study 2. Modification of muscle structure following physical therapy, myotonometric analysis.

A group of 12 patients with Parkinson's disease from the study group of the work *Determining the muscle parameters of patients with Parkinson's disease before and after drug treatment with the help of myotonometry* were also measured in another study that followed to what extent the muscle structure changes according to the physical activity proposed within the rehabilitation program that aimed to improve body posture and alignment.

The main aim of the study was to observe what changes occur in the muscle structure of the four targeted muscle groups: pectoralis major muscle, biceps brachii, biceps femoris, tibialis anterior.

Material and methods

The participants were tested before starting the rehabilitation program, the muscle examination was carried out in a relaxed state. The four muscle groups were tested in the following order: pectoralis major, biceps brachii, biceps femoris, and tibialis anterior. After completing the proposed program, the patients were retested in the same manner.

Research results and conclusions

State of muscle tension – Regarding the state of muscle tension, higher values of the state of muscle tension were recorded before the patients went through the rehabilitation program. There are positive changes, especially in the pectoralis major and biceps brachii muscles. This positive result demonstrates the benefit of physical therapy in reducing the muscle stiffness present in most patients with Parkinson's disease. Also, another notable aspect observed after the interpretation of the results is represented by the modification of the parameters in the area of the muscles of the upper trunk (pectoralis major) and the upper limb (biceps brachii), where emphasis was placed in the program on stretching the muscles and exercises to correct the posture.

Dynamic stiffness – At the level of the pectoralis major, biceps brachii and biceps femoris muscles, it can be seen through the graphic representation exemplified in the thesis that the state of dynamic stiffness, which shows the resistance to a contraction or an external force that deforms the initial shape of the muscle, is changed in a positive sense following completing the exercises in the recommended program. This result demonstrates that the condition of the muscles has changed, becoming compliant (elastic).

Muscle elasticity – Regarding the logarithmic decrement - the elasticity of the targeted muscle groups best represented at the level of the lower limb muscles, this result shows that the muscles of the lower limbs recover their shape faster after it has been deformed during the repetition of the exercises. This result also demonstrates why handedness and dexterity in the upper limbs is altered due to the limited level of elasticity as well and why patients experience difficulties during daily activities.

Mechanical relaxation time – The relationship between the relaxation time and the deformation characterizes the gradual elongation of the tissue when the muscle is subjected to a constant tensile stress. Positive results are identified in the muscles of the lower limbs (biceps femoris and anterior tibial), as in the case of logarithmic decrement. There is a positive correlation between the two elements, elasticity and relaxation time respond better to the muscles of the lower limbs. The medical rehabilitation program for the lower limbs had as its objective the extension of the knees and the prevention of the semiflexion specific to the posture of Parkinson's disease. The exercises had a positive effect producing effects at the level of the mentioned musculature.

Deformation ratio and relaxation times – Regarding the deformation ratio and the relaxation times, we can say that, before the program was carried out, the patients experienced a state of excessive stiffness that decreased considerably, producing a faster relaxation of the muscles. Following the completion of the program, this result reflects a high level of functionality that patients feel after medical rehabilitation programs.

Study 3. Postural analysis of patients with Parkinson's disease and the importance of kinesitherapy in changing postures

The purpose of the study is to identify whether changes in the posture and body alignment of patients with Parkinson's disease occur following the kinesitherapy program.

The method of postural evaluation with the help of the GaitOn Posture Analysis software consists in determining the alignment of the spine, the pelvis and the lower limbs by analysing the axes following the import of images made with the help of markings at the level of the analysis areas.

Material and methods

The sample consists of 40 patients, aged between 52 and 75 years; According to the Hoehn and Yahr staging, the participants in the study are distributed percentageally in stage II 40% and stage III 60% respectively.

The measurement procedure takes 10 minutes per patient and consisted of applying Markers to the analysis areas and then photographing the patients from three angles: anterior, lateral and posterior. For the analysis, the patient is evaluated from three angles; *Anterior view*: the Marker is positioned at the level of the anterior-superior iliac crest, the centre of the patella and on the tibial tuberosity. *Posterior view*: the Marker is positioned at the base of the calcaneus, insertion of the Achilles tendon, centre of the Achilles tendon. *Lateral view*: the Marker is positioned at the level of the C7 spinous process, the midpoint of the humeral head, the greater trochanter of the femur, the lateral epicondyle of the femur, the lateral malleolus.

The duration of the recovery program was between 45 and 90 minutes with a frequency of 2 times a week. The physical therapy program included a number of 15-20 exercises per session, the frequency of the exercises and the intensity was varied between the patients according to the exercise capacity.

The kinesitherapy program itself was carried out with an emphasis on the upper trunk area, starting with the cervical area, shoulders, chest, then toning the pelvic muscles and finally promoting the extension of the knees.

Results

We analysed the body posture before and after the kinesitherapy program and statistically significant changes can be observed before and after the treatment in terms of the values of the angles with which the head tilts against the reference value of 0° as well as in terms of shoulder alignment a statistically significant improvement is identified. Positive results are also in the case of pelvic alignment an improvement can be seen in the difference between the angle with which their pelvis tilts and the reference value of 0°, it is greater before treatment than after treatment, the difference is statistically significant.

Conclusions

The GaitON Posture Analysis program is a good indicator for assessing and monitoring posture and alignment. With its help, you can particularly identify elements of finesse in terms of the position of the head, shoulders, pelvis, knees or soles that can be corrected by means of kinesitherapy programs.

The kinesitherapy program proposed to patients with Parkinson's disease for postural modification has been shown to be effective because it has brought about positive changes in the alignment and correct repositioning of the head, shoulders, trunk and pelvis in physiological parameters. The program also has a prophylactic effect in that patients who had deviations within normal limits remained throughout the kinesitherapy program without having an unfavourable evolution considering the progressive evolution of the disease.

Another notable element regarding the kinesitherapy program is the way it was carried out and the attention to how the patients performed the program because the results showed that following the program there were no negative imbalances from the previously analysed values and the posterior analysed values which means that the patients were properly supervised during the program.

Study 4. Compliance of Parkinson's disease patients to kinesitherapy programs for posture correction through group therapy and individual therapy

The purpose of the study is to identify the view of patients with Parkinson's disease regarding the role of physical therapy, the benefits and the results obtained from this type of therapy.

Another goal is to prove how the recommended kinesitherapy programs help to change the functional status.

The survey in the form of a self-composition questionnaire applied in the present research converts the research objectives and hypothesis through appropriate questions, which are addressed in clear terms, thus making it possible to collect some truthful information from the respondents; these questions are about the phenomena encountered in the recovery process.

Material and methods

The questionnaire was applied to patients before they were involved in kinesitherapy programs specific to Parkinson's disease, but also after 6 months in which they took part in the proposed sessions.

A total of 29 patients with Parkinson's disease participated in this pilot study. Two types of therapies have been proposed: individual therapy and group therapy.

In order to be able to see the difference between the condition felt by the patients before inclusion in the program, they completed the MDS-UPDRS questionnaire in the section for patients. Part I- Non-motor aspects of physical activity- Pain and other sensations, Part II- Motor aspects of activities of daily living- hygiene, hobbies and other activities, getting out of bed, car, chair, walking and balance, Part III- stability and balance.

After a period of 6 months, all the patients involved in both types of therapies received the MDS-UPDRS questionnaire again, as well as a questionnaire in the form of a self-composed opinion survey with 15 questions about the perception of physical therapy procedures, the way they are carried out, the importance of physical therapy for the favourable evolution of the state of health, the flexibility and understanding of the therapist, the degree of difficulty of the programs, the emotional and physical state felt during the physical therapy sessions, the recommendations and their implementation and the degree of satisfaction regarding the recovery program and finally which type of therapy (individual or group) fits and in which the patient feels best.

Results and conclusions

The compliance questionnaire for physical therapy programs is a valuable tool, easy to measure and analyse, the data provided bring important elements for the therapist in building and placing patients in specialized programs.

With the help of the results, we were able to classify the patients according to their preferences for individual or group kinesitherapy, also analysing their emotional state, important elements in the involvement and performance of the activity. We also understood the perception of the difficulty of the programs, the way of attendance, aspects that positively influence the condition of the patients, the way of communication with the therapist and the perception of the patients regarding the role of kinesitherapy in Parkinson's disease.

The results also showed the level of satisfaction with the kinesitherapy program which is dependent on the mental state acquired during the participation in the recommended programs. The better the patient's mental state during the physical therapy sessions, the higher the frequency, self-esteem, satisfaction with the program and the level of quality of life. With the help of kinesitherapy, the patients had a significantly positive evolution of the functional status.

The two questionnaires brought us relevant information that equally contributed to the construction and optimization of the recovery program strategy.