

THE UNIVERSITY OF MEDICINE AND PHARMACY

"CAROL DAVILA", BUCHAREST

DOCTORAL SCHOOL

MEDICINE



*Research on main methodological options in virtual reality (VR) mediated
interventions for remedial treatment in balance disorders in adolescents with
cerebral palsy (CP)*

PHD THESIS SUMMARY

PhD supervisor:

PROF. UNIV. DR. ONOSE GELU

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"I thank God for the help offered through the people I met during my professional training and who unconditionally supported me in the scientific foundation as well as in the elaboration of this doctoral thesis - which would have been impossible without the help, the support and the guidance of these entities - who, through their high professional degree and dedication, contributed to my formation as a researcher, instilling in me the knowledge, perseverance and courage to move forward."

INTRODUCTION

The subject of the Doctoral Thesis "Research on the main methodological options in interventions mediated by virtual reality (VR), for recuperative treatment, in balance disorders in adolescents with cerebral palsy (CP)" I considered it appropriate, thinking that for people - due to specific posture and mobility: standing and walking, bipedal - the static and dynamic balance of the body and, respectively, its positioning in conditions of sequential stability [efficient/propensive, including for coordinated movements, sometimes extremely complex, performed with the upper limbs (1) – necessary for characteristic anthropic activities, such as ADL (activities of daily living) and/or lucrative], represents a feature and at the same time a key determinant of our functioning(2).

"... an item still incompletely resolved - and topical - remains the problem of managing and maintaining balance."(3) ... thus "recovery being a major component for fall prevention; ... part of the neuromotor impairment"(4), in existing pathologies; as such, I decided to choose the issue stated in the title as the main subject of this paper.

So, I have followed internationally – over the years – in the specialized literature [case studies(5–7), research / original works, websites, etc.] how numerous materials have been presented(8,9) , in which the importance of Virtual Reality (VR/augmented) is exposed in various fields of significant importance: – military(10,11), cinematography(10) medicine(12,13), fitness(14), medical/aerospace/automotive engineering as well as in the areas of education and entertainment respectively(15), with the explanation and demonstration(16,17) of the applicability and benefits(18) - in the short and long term - of training, recovery of balance disorders and instability, as the main objective in patients with

PC – interventions focused on (re)performance(19) and (re)learning, motor(20), results reported as having favorable results(21,22).

"Beyond the distraction and entertainment created, virtual reality can deliver an artificial psychological and physiological, corrective environment and facilitate the recovery of pediatric patients suffering from chronic pain"(23) as well as the neuromotor recovery of children with cerebral palsy, spinal amyotrophies, muscular dystrophies (Duchenne, Becker), cranio-cerebral trauma(24), vertebro-medullary, etc.

At the same time, we mention the fact that in addition to RV/augmented, in the modern diagnostic and therapeutic-recuperative arsenal, with the purpose stated in the title, advanced, convergent devices and interventions are used - and we also use them - in the approach to balance disorders: "PRO-KIN 252"(25) (in order to encourage the active participation of the adolescent patient, we used one of the many assessment/stimulation and training devices on the market using augmented virtual reality, with which we were able to follow the proposed objectives and transpose the exercises necessary from classical physical therapy to that related to modern robotic recovery, with more joy, ease and intrinsic motivation(26) (I specify that I carry out my activity and I carried out this Doctoral Thesis within the National Clinical Center for Neuropsychomotor Recovery for Children "Dr. Nicolae Robănescu", this medical unit being the first in Romania to benefit from this medical device since 06-21-2016 - see annex 14), including for adolescents with CP.

"PRO-KIN 252" is a "top" medical device, as a technological innovation in the recovery of static and dynamic balance, with up to 50 levels/settings of electronically controlled instability; is equipped with: a sensitized platform containing 4 force cells, which measures COP (center of pressure) activity at the plant/leg level and a sensor applied to the patient's xiphoid appendage (TRUNK SENSOR) which measures trunk oscillations .



Annex no. 14. Physiomed commercial company declaration of uniqueness, delivery and surrender of the "PRO-KIN 252" Device in Romania within the CNCRNC Dr.

"Nicolae Robănescu"

Another advanced recuperative assistive device we used is the "G-EO EVOLUTION": this robotic system helps patients by supporting the correct movement compared, as feedback with corresponding representations from an immersive virtual environment, both during walking and in activities more complex such as going up and down the stairs, in an immersive virtual environment - by applying 3D virtual reality glasses with the aim of improving movement patterns (aiming to resume orthostatism and walking as close as possible to physiological) (27).

The "MYRO" interactive surface - equipped with tactile/haptic movement capture sensors, where the recovery plan becomes creative, engaging - activates and demands the cognitive system with a multitude of applications aimed at recovering the ability of the upper limbs (uni) bilaterally, including/in mainly in neurological, trauma recovery interventions and more(28).

I also used the "Nirvana" augmented VR system in neuro-motor recovery, including in patients with PC, this device through multisensory stimulation, with illustrations displayed on the wall or floor(29).

The doctoral research approach that I proposed aimed at the impact of RV/augmented in the traction and recovery of adolescents [it is important to specify that puberty begins

approximately at 8-10 years(30), being followed by adolescence between 13-19 years(31,32)] with CP and balance disorders, following two important aspects:

1. The attempt to clarify what is not fully standardized: the related "dosage" (8,33,34), in the context of a comprehensive approach to the physical methods of recuperative treatment in the mentioned pathology;

2. Considering/respecting, as a related but also priority objective, the safety of our patients regarding the application of RV/augmented procedures.

Of course, the achievement of these objectives is a complex approach that involves the subsumption of standardized clinical and instrumental assessment approaches and elements of advanced technology.

As will be seen both below and throughout the present PhD Thesis.

In order to carry out this doctoral work, I pursued and achieved:

- obtaining approval for the conduct of the related clinical study, from the Ethics Commission and respectively from the manager in charge of this Institution
- ensuring the information of the participants and completing the Informed Consent of the patient/his parent

- application of the following clinical-functional assessment scales – including apparatus (see below).

- interpretation - including objectification based on related statistical analysis - of the data obtained.

We specify the fact that, unfortunately, given that, as is known, there is still no intervention modality (pharmacological, physiatry, neuro-surgical, regenerative medicine/tissue engineering, etc.) capable of effectively healing the injuries of the nervous system central (CNS)(35) - including CP - any attempt to improve/optimize therapeutic-recovery in this extremely difficult field of pathology is still of urgent relevance, considering also the marked disabling potential of this category of conditions.

At the same time, we mention the fact that in the literature - to the best of our knowledge - we have not found any works focused on this target population: adolescents with CP and consecutive balance disorders, with their therapeutic-recuperative approach, in a multi-level physiatry complex, including using advanced physical therapy devices and especially in association with RV/augmented procedures.

Working hypothesis:

If there are significant differences from the point of view of the recuperative results obtained between the doses used of RV/augmented, in the context of the complex, integrated recuperative physiatry approach, in adolescents with CP and consecutive balance disorders with CP, and if so, what is the related methodological formula more efficiency.

The thesis is structured in two parts:

The general part, containing 3 chapters, including theoretical data - including based on a systematic review of related literature ["Data on advanced physiatry approaches of stabilometry and virtual reality for assessment and (re)training of balance in cerebral palsy"(36) regarding CP and the consequent balance disorders, as well as ways of testing/quantified evaluation and respectively recuperative physical-kinetological interventions, including advanced apparatus, for the recovery/retraining of balance in adolescents with such pathology.

The special part (original - personal contributions) includes the working hypothesis, the established objectives - succinctly stated above - and the research methodology, used as well as: a pilot study (Study I) - "Evaluation modalities and physical therapy, apparatus, advanced, coordinated methodological, to address static and balance disorders in pediatric patients with cerebral palsy (CP) - preliminary results"; Study II, entitled "Our experience regarding the effects of some advanced physical - kinetological recuperative treatment methods in balance disorders in adolescents with cerebral palsy - (partial results)"; Study III, entitled: "Final data - on numerically increased groups/lots and with related optimization of the statistical analysis methodology - regarding the effects of some advanced methods of recuperative physical-kinetotherapy treatment in balance disorders, in adolescents with cerebral palsy".

This research took place between October 2017 - February 2023, within the CNCRNC "Dr. Nicolae Robănescu", Bucharest, on three target groups/groups: two study groups/groups (adolescents) and one control/control (all with CP and consecutive balance disorders), the study groups/groups totaling 163 patients and one control/ control, 89 such pediatric patients, respectively a control/ control subgroup/ subgroup of 13 adolescents with CP (see below).

As the only usable group/ control group/ control (pediatric patients with CP who only performed physical therapy, comprising 89 cases), we opted for its use in its entirety due to the statistical power provided by the relatively large number of such patients.

However, given the fact that there were only 13 teenagers in this group/batch, for added rigor we performed the same comparative statistical analyzes using this (sub)group/(sub)batch of teenagers with CP as a control.

Thus, we found that, although the statistical power was inevitably lower, from the point of view of the significance of the results obtained, they do not differ significantly from those found in the comparisons made using the initial control group/group (consisting, in total, of 13 teenagers and 76 children = 89 pediatric patients with PC, in total).

Concretely, from the comparative analysis of the effects obtained by the therapeutic-restorative methodology used - and objectified by the above-mentioned quantified clinical-functional assessment tools - we found that the patients in the "intensive" group/batch (see further) had overall statistically significant results better than those in the "moderate" group/lot and respectively from the control/control group (/subgroup)/lot(/subplot).

A possible limitation of the present research carried out/in the elaboration of this Doctoral Thesis, is (in addition to the mixed composition: children plus adolescents of the group/ control group/ control in its entirety and, respectively, the smaller number of cases of the adolescent patient component of within the control subgroup/subgroup) the options expressed by the respective parents regarding the voluntary placement in the "moderate" or "intensive" group/group, taking into account aspects of balance (including subjective elements) between the desire/confidence - of principle, natural - and the psychological "investment" in a procedural complex with a more pronounced profile and, respectively, the concern for a potential risk of additional patient fatigue - see below).

The results obtained constitute, we consider, a personal contribution to the objectification of the theoretical and practical knowledge base for the use of RV/augmented dosages, which can be used within the optimized, multimodal approach of modern complex, therapeutic-recuperative physiatric treatment of cerebral palsy with consecutive disorders of balance, in teenagers.

GENERAL PART

Theoretical aspects related to the researched pathology – cerebral palsy (CP)

Definitions

Several definitions have been added to it, over the years there have been conceptual and approach differences, several authors trying to reach an agreement on the definition and multidisciplinary approach of this pathology (37); thus some of the authors attribute the term "umbrella" (symbolistic association) to it, and refer to the vast group of non-progressive disorders, more precisely - neuro-psycho-motor type (38) - so PC is considered to be a disorder of posture, movement, voluntary control and motor development, which determines the limitation of activity over time (sometimes with changes along the way) - triggered in an immature brain (39).

Etiological data

The postnatal development of the brain takes place majorly in the first two years of life and that the lesions that occur in the immature brain are the ones that determine the appearance of CP, which can be: prenatal/congenital (before birth and represent approximately 75% of CP cases), perinatal (during birth/before term 6-8%), postnatal/time after birth (especially in the first 2 years of life 10-18% (40)).

Classification

In the relevant literature, a classification system approved by the American Academy for PC, used since 1956 (22,38), is found, which describes 7 mortic types of this morbid entity: spastic, athetic, rigid, with present tremor, hypotonic, mixed , unclassifiable (41).

Assessing the functioning of the adolescent with PC-generated disabilities

Currently, there are a number of scales or systems of quantified clinical motor classification, which highlight/measure the functional deficits within PC.

It should be noted that: a large number of such scales can be found in the literature (almost 30 - not used exclusively in PC "Communication at the National Congress of Physical Medicine, Recovery and Balneology - with International participation", Covasna 2021) (42).

We present here two such quantified clinical-functional evaluation scales, which we used, along with 5 instrumentally measured evaluation parameters (see below) in this Doctoral Thesis.

Synthetic notions of morpho-physiology regarding postural balance and its main changes in adolescents with CP

Morpho-physiological aspects regarding human postural balance – in orthostatism and walking

Ostrostatism and biped walking, human, with the required postural balance - static and dynamic - related, are extremely complex and efficient physiological functions but not easy to achieve (with increased risk - as the "price" of this decisive biological advance of ours in / compared to the animal kingdom - of falls, especially when there are/ appear disturbances/ dysfunctions within one or more of the numerous and subtle components of this function), which represents, as a whole, a brilliant progress and phylogenetic success, constituting at the same time, defining features of our species.

Achieving balance in standing and walking and (through recovery and/or support reactions) its restoration, under the conditions of inevitable dynamic challenges, generated by very varied and important constituents of our current activities, is ensured "infrastructurally", synthetically - subsumed by a pattern of bio-cybernetic functioning and control, based on feedback/ forward processes - of components of the "neuromyoarthrokinetic apparatus" (43) - more precisely of "musculo-skeletal" structures, respectively - n. n.

– "visual, vestibular" as well as "cutaneous" but also "psycho-emotional" interferences) (44)



Fig. 2.6. "9804. Sensor-motor integrations. At the origin of a function-oriented rehabilitation as neurologic impairment: "... require approach, re-approach to activities...".
Source: Adapted from: "Physical and Rehabilitation Medicine, 4th Edition" (2010), Elsevier, Department of Neurorehabilitation Sciences, Institute of Physical Rehabilitation, University of Medicine and Pharmacy "Carol Davila" Bucharest, Romania.



Fig. 2.7. (Left) sensor-motor integrations. At the origin of a function-oriented rehabilitation as neurologic impairment: "... require approach, re-approach to activities...".
Source: Adapted from: "Physical and Rehabilitation Medicine, 4th Edition" (2010), Elsevier, Department of Neurorehabilitation Sciences, Institute of Physical Rehabilitation, University of Medicine and Pharmacy "Carol Davila" Bucharest, Romania.

Physiopathological data regarding static and dynamic balance disorders – in adolescents with CP

CP is the most "common" cause of motor disability in children (45) and as it is a chronic/"permanent" condition (46) - as is known, unfortunately, at the present time there is

still no pharmacological, natural or synthetic agent or type of therapeutic intervention (including surgical or physiatric) able to effectively cure CNS lesions (35) - its sequelae [(CP being defined as "a neurological disorder generated by a brain injury non-progressive or by a malformation, which occurs during the time when the child's brain is developing" (47) disabling - are "primarily affected": "body motility and muscle coordination" (47) - continue to exist even in adolescence.

Morpho-/physio-pathological bases.

As a morpho-dysfunctional substrate, the main tissue types/areas of localization of neuro-lesions in PC (identifiable by imaging - especially nuclear magnetic resonance (NMR) is considered, including for this purpose, a very contributing investigation - are: "predominantly of the substance periventricular white matter, predominantly of the gray matter, cerebral malformations, others" (48); they appear predominantly in affected areas of the brain - with topographical distributions corresponding to the neuro-dysfunctions/consecutive disabilities - such as: the parietal lobe (found in clinical-dysfunctional correlation with " gait profile score"); the periventricular shell (found in correlation with the Gross Motor Function Classification System - GMFCS score); the anterior part of the corpus callosum (found in correlation with "variable gait scores") (49) in the cerebellum - associated with some ataxic forms (in "extrapyramidal/non-spastic" PC) - (50), with presence, also encountered, variable, in such forms - for example, on CT: "frequent but variable", widespread in " simple ataxia" (and with - n. n.) "imbalance" - including (but) in the parietal lobes, posterior fossa, vermis, in hydrocephalus (51).

Clinical-dysfunctional aspects

More detailed clinical-functional classifications of CP are those belonging to the 'Surveillance of Cerebral Palsy in Europe (SCPE) Collaborative Group, CP' - according to which this condition can be: spastic, ataxic-dyskinetic and unclassifiable (52) - and respectively, the one developed by Swedish authors, which proposes the taxonomic division of CP even more thoroughly: "spastic (hemiplegic, tetraplegic, diplegic), dyskinetic (dystonic and athetotic), ataxic and unclassifiable/mixed".

So, postural balance is "a key problem for children with CP"(53).

Methods of testing and, respectively, physical therapy interventions, including advanced equipment, for the recovery/retraining of balance in adolescents with CP.

Concept-methodological aspects related to the clinical (non-apparatus) testing of balance disorders

In order to be able to evaluate the state and conditions of equilibrium/re-equilibration, numerous tests for detection/quantification of disorders of this function can be used.

The use of such tests - including those of the apparatus type - also helped to a more comprehensive description and understanding of the complex processes that compete to maintain stability.

Generally, such a test is repeated three times and the best result is chosen; eg: Sensitized Romberg, Leg Test, Berg Scale, Movement Skills Scale, Fukuda Test, Bass Test, Timed Up & go Test, Tinetti Test.

Conceptual and methodological aspects related to testing and, respectively, to physical-kinetic therapy interventions of the apparatus type, advanced

Modern instrumental movement evaluation techniques offer the possibility of inclusive quantification of the effects of the pathology involved in orthostatic balance and gait disorders as well as the establishment of recovery/ reeducation strategies, on coherent, scientific bases.

Stabilometry is the objective study, through force plates, of the balancing/balancing of the body during the rest/ "quiet" state, with possibilities for quantified evaluation. Stabilometric analyzes in addition to orthostatism, without active movements, can also target passive/externally induced movements, for the trunk and upper extremities; such assessments can also be done from a sitting position (54).

Thus, the "hard" infrastructure of an apparatus such as the "PRO-KIN 252" (mentioned and presented previously) ensures the passive balancing - challenging for rebalancing - the movements generated by the force plates of the apparatus together with its dedicated software/ applications, provides – as continuous guidance/ training feedback – the ideal/optimal line that the patient must follow to recover balance, posture and then/also gait and related dynamic rebalancing – with the consequent decrease in the risk of falling (55) – and, furthermore, autonomy, as well as quality of life (QOL).

Some specific considerations, within the related activity and ours respectively:
Assessment and intervention facilities mediated by virtual/augmented reality:

As elements of the Classification of VR/augmented facilities/interventions, we consider necessary in advance some considerations regarding evaluation and intervention facilities:

"Virtual reality (VR - or virtual environment, MV) - can be defined as a computer/computing technology that generates a three-dimensional (3D) simulated/artificial environment that imitates reality"; in principle, its infrastructure (hardware and software) must produce a "convincing" virtual environment capable of allowing the user to interfere with it in the most "naturalistic" way possible(56).

From the beginning, a related detail is also necessary: in addition to VR there is Augmented Reality (AR), which includes a series of facilities, also based on computer science, to enhance multisensory perceptions, through additional stimuli such as - apart from those visual – auditory, olfactory and respectively tactile/haptic stimuli, many of which combine with the physical/real, surrounding environment (from which the user is not disconnected) specifically, by adding/superimposing on reality, of "...a synthetic elements such as 3D images, multimedia content elements or/and text information superimposed on real-world images", to improve multimodal interactivity in a new-complex environment: digital-human... (57).

Types/virtual reality devices - provided by CNCRNC "Dr. Nicolae Robănescu" and used in the Clinical Study related to my Doctoral Thesis.

Specialized device for evaluation, quantification and stimulation/retraining of static and dynamic balance (based on proprioceptive and visual feedback) "PRO-KIN 252" (25).



Fig. 3.1. (din cazuistica CNCRNC "Dr. Nicolae Robănescu" pe bază de consumjământ informăţ - adolescenţi cu PC - "Testarea probei Romberg" şi măsurarea "Indicelui de stabilitate globală (bazat pe echilibrare la joacă orizontală)", efectuate cu ajutorul Dispozitivului Avansat "PRO-KIN 252"



Fig. 3.5. (din cazistica CNCRNC, pe bază de consimțământ informat – adolescenți cu PC: stimularea și antrenarea mișcărilor globale ale membrilor inferioare (reeducarea mersului și implicit al echilibrului postural static și dinamic efectuate cu ajutorul dispozitivului – asistiv recuperator robotic "G-EO EVOLUTION" și RV imersivă, utilizând HMD

The main arguments in favor of choosing these interventional options were:

As a fundamental first stage condition – serious games (SG) feature complex and interactive graphics, an attractive/engaging environment for the user.

They ensure for the user/patient an important role of cognitive stimulation, through which we aim to maximize his active and conscious involvement, the prolongation of the procedural period - as an echo of the improvement of the motor system (positive feedback) - obtaining favorable results by completing the tasks (58).

Through a series of assistive-multimodal tools, SG have the property to recognize and assist body movements (passive, passive-active, active, active with resistance, coarse and/or fine) in real time.

At the same time, they enable the user's attention and change the behavioral attitude, through motivation and the desire to overcome oneself - to slow down and accelerate the recovery period (59).

General research methodology

The study was carried out in the fourth quarter of 2017 - the approval was obtained from the Ethics Commission - No: 7661 of: 19.10.2017 - within the CNCRNC "Dr. Nicolae Robănescu", Bucharest and targets teenagers with CP, to address the re-education of their consistent balance disorders, using, as a therapeutic-recovery means, key tools of motivation/participation and related improved re-learning, VR/augmented facilities (VR/AR) and robotics.



AVIZ STUBUR CLINIC

Comisia de Etică a Centrului Național Clinic de Recuperare Neuropsihomotorie Copii "Dr. Nicolae Robănescu" avizează efectuarea studiului științific, cu respectarea normelor de etică a cercetării științifice, în scopul realizării Tezei de Doctorat cu titlul "Cercetări referitoare la principalele opțiuni metodologice în intervenții medicale prin realitate virtuală, pentru tratamentul recuperator, în tulburări de echilibru la copiii și adolescenții cu paraliză cerebrală (predominant) ataxică" a domnului Kinoteropest Avram Radu Mihail.

Președinte Comisia de Etică,
CNCRNC "Dr. Nicolae Robănescu"

AVIZ PENTRU ANEXA NR. 13

Appendix no. 12. Favorable opinion from the Ethics Commission of CNCRNC "Dr. Nicolae Robănescu" for conducting the clinical study related to the Doctoral Thesis - 19.10.2017

Formularul de consimțământ informat.

Subiectul (nume, prenume, sex, data nașterii, adresa, telefon, e-mail, etc.)

CNP: Serviciul în localitatea: nr. bl. sc. et. ap. sector: județ: telefon: legătură cu: adresă: în calitate de reprezentant legal al copilului dispunând cu **putere cerebrală**, de acord pe propria răspundere următoarele:

Am luat la cunoștință că în cadrul departamentului de Stabilitate al CNCRNC "Dr. Nicolae Robănescu" se desfășoară proiectul științific denumit "Cercetări referitoare la principalele opțiuni metodologice în intervenții medicale prin realitate virtuală, pentru tratamentul recuperator, în tulburări de echilibru la adolescenții cu paraliză cerebrală" și întocmesc prezentul consimțământ informat în exprimarea acordului și detailez rezultatele din evaluările mele împărate, cu datele medicale și informațiile personale, să fie folosite de cercetătorii științifici în scop științific și didactic cu respectarea normelor de confidențialitate în vigoare.

Subiectul (numele pacientului/reprezentantului legal) declară că am înțeles toate informațiile furnizate de Radu Mihail Avram - Kinoteropest în cadrul Centrului Național Clinic de Recuperare Neuropsihomotorie Copii "Dr. Nicolae Robănescu" și îmi exprim acordul informat de a participa la studiu.

Semnătura pacientului sau a reprezentantului legal: Data: Numele pacientului sau a reprezentantului legal: Ora: Subsemnatul Radu Mihail Avram certifică că am urmat procedurile necesare obținerii consimțământului informat al pacientului.

Pacientul/detectorul acordă a lucra, natura și scopul studiului și a consimțământul participării (copiului) la studiu. I se dat oportunitatea de a cere clarificări sau corecturi, să fie satisfăcătoare.

Semnătura reprezentantului CNCRNC: Data: Numele reprezentantului CNCRNC: Radu Mihail Avram Ora:

Am înțeles că alături de beneficiile care pot fi obținute din participarea la studiul științific pot exista și unele riscuri sau inconveniente, care pot fi evitate sau reduse prin respectarea următoarelor condiții:

- scopul studiului, durata acțiunii și criteriile de selecție a pacienților;
- procedurile care se vor desfășura în cadrul studiului;
- locurile și metodele participării la studiu;
- posibilitatea de a mă retrage în orice moment din acest studiu;
- confidențialitatea datelor personale;
- lipsa costurilor asociate participării la studiu;
- date de contact la care să pot solicita informații suplimentare.

Am înțeles că alături de beneficiile care pot fi obținute din participarea la studiul științific pot exista și unele riscuri sau inconveniente, care pot fi evitate sau reduse prin respectarea următoarelor condiții:

Anexa nr. 13. Formular de Consimțământ Informat, aprobat de Comisia de Etică a CNCRNC "Dr. Nicolae Robănescu".

Anexa nr. 13. Formular de Consimțământ Informat, aprobat de Comisia de Etică a CNCRNC "Dr. Nicolae Robănescu".

Statistical processing methodology

For statistical processing, demographic data and descriptive statistics were calculated and comparison tests were used - Kolmogorov-Smirnov (K-S) and Shapiro Walik (S-W) - for normality, respectively parametric (type t/ ANOVA - with situational adaptations specific through post-hoc tests: Tamhane, respectively Fisher's Least Significant Difference), non-parametric (Mann-Whitney U./ Wilcoxon W./ Z. Kruskal-Wallis H.).

We first calculated the delta concept for each of the four variables associated with the Romberg test, performed both in the situation with O.E. as well as in the situation with C.E.; for this purpose the formula applied was: $(T1-T0) * 100 / T0$.

The personal scientific research carried out within this Doctoral Thesis consists of three clinical studies:

- Pilot study (I) on "Methodologically coordinated, apparatus-based, advanced physical therapy assessment methods for addressing static and balance disorders in pediatric patients with cerebral palsy (CP) - preliminary results" (poster awarded in the section for doctoral students of the Congress of the Romanian Association from 2019);
- Study II "Our experience regarding the effects of some advanced physiokinetic recovery methods on balance disorders in adolescents with cerebral palsy - partial results; (Data regarding physiatric advanced approaches of stabilometric and virtual reality for balance assessment and (re)training in cerebral palsy"); - where I published a synthesis of the documentation base, knowledge in the issue addressed in this doctoral work in the form of a systematic literature review (rigorously carried out according to the widely accepted and used international methodology: "Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA));
- Study III "Final results, on extended groups/lots with increased statistical power, regarding the results obtained by applying some advanced physical-kinetotherapy recovery methods on balance movements in adolescents with cerebral palsy (CP)":

The Pilot Study (I) concerned a group/batch of 14 patients aged between 13-18 years (156-216 months) who underwent the "intensive" methodological formula for a total duration of recuperative treatment of 90 minutes - (see May far annex no. 1); Study II included 89 patients - (of which 14 representing adolescents with CP and consecutive balance disorders from the Pilot study) - 40 in the "moderate" group/lot, with a methodological dosing algorithm related to a total duration of recuperative treatment of 75 minutes and 34 in the "intensive" group/batch, with a methodological dosing algorithm related to a total recovery treatment duration of 90 minutes [of which 14 from the Pilot Study(I)]; we remind you that all patients in the two groups/study groups were teenagers, aged between 13-18 years (156-216 months); Study III (final) "Final results on extended groups/lots with increased statistical power", was started by adding patients (34 in the "moderate" group/lot, respectively 55 in the "intensive" group/lot) - to the two groups/lots study [(reaching a total number of 163

patients) 74 in the "moderate" group/lot and 89 patients in the "intensive" group/lot]), all adolescents aged between 13-18 years (156-216 months).

Thus, a numerically consistent increase was achieved in each of the two study groups/lots corresponding to a propensity statistical power for valid/reliable results of the related mathematical processing.

In order to quantify the functional status of the patients enrolled in the two study groups/groups and to objectively evaluate the effectiveness of the applied physical-kinetic therapy programs, we performed standardized measurements using seven quantification scales, of which two clinics (those numbered 6. respectively 7. - see below) and equipment - stabilometric/posturographic type measurements [(five measurements performed using the PRO-KIN 252 Device, provided with: a platform containing 4 force cells, which measures the activity of the COP (center of pressure/ pressure center) at the level of the plants and a sensor applied to the patient's xiphoid appendage (TRUNCK SENSOR)] – extracted from the tests performed: "Romberg" and "Global stability index (ISG)" based on horizontal bipodal balancing, expressed in degrees platform inclination [(within the device it is found under the name ('Stability Index') - "PRO-KIN 252")].

The image displays three overlapping screenshots of the GMFM-66 software interface. Each screenshot shows a table of tasks categorized by dimensions (Lying & Rolling, Sitting, Crawling & Kneeling, Standing, Walking, Running & Jumping). The tasks are numbered and include descriptions of the activities. Performance is recorded for each task across five dimensions (0, 1, 2, 3) and a 'Not Attempted' (NT) category, using a scale of circles.

Anexa nr.5. Soft de analiză și măsurare a funcției motorii grosiere referitoare la parametrul/ pe scala (GMFM-66)
Gross Motor Function Measure

Thank you for purchasing a license for the
GMFM app+!

Link for downloading is:
<https://forms.gle/GzMLcGEY1yz4iX2t9>

Password: CanChildwin2019

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Anexa nr.6. Licea individuală de utilizare a Scalei de măsurare a funcției motorii grosiere Gross Motor Function Measure (GMFM)-66

Inclusion criteria:

- When establishing the groups/groups analyzed in this Doctoral Thesis, we considered the following: pediatric patient (in the two study groups/groups mainly adolescents) with a medically confirmed PC diagnosis; no neurological conditions other than CP; stable clinical-biological general condition, without organ failure; the informed consent signed by the parent/legal guardian - a measure fulfilled since admission for all patients admitted to CNCRNC "Dr. Nicolae Robănescu", aged between (13-19 years - eminently teenagers); patient able to understand and cooperate in all the procedures of the complex therapeutic-recovery program;

Exclusion criteria:

- Refusal of patients/legal guardians to be included in the study; the presence of associated severe musculoskeletal/algic pathology; altered general condition and/or organ failure; cognitive-behavioral disorders capable of affecting the therapeutic-recuperative act; patient who underwent surgery less than 12 months ago;

After considering the inclusion and exclusion criteria, we constituted the two study groups/groups totaling 163 patients (74 in the "moderate" group/group - 75-minute algorithm of the therapeutic-recovery program - 89 in the "intensive" group/group - with the algorithm of the 90-minute therapeutic-recuperative program; it should be noted that we initially recruited 170 teenagers with CP and consecutive balance disorders, but 7 of them did not complete the "moderate" therapeutic-recuperative programs, respectively "intensive.

We specify the fact that the group/ control group/ control of 89 patients (constituted retrospectively) was taken from the Doctoral Thesis of the Associate Professor Doctor Andrada Mirea with the kind consent of her lordship - being selected precisely because it lends itself to the comparison between the groups/ study groups, patients being tested with the Gross Motor Function Measure evaluation scale (as a link and comparability element) and the second argument – these patients performed only 22 (2/day on weekdays and 1/day

on weekends, respectively) physical therapy sessions, which are carried out during a hospitalization (with a 12-day hospitalization) within the CNCRNC "Dr. Nicolae Robănescu" - each meeting lasted 30 minutes and we did not take new cases as a witness/control because - considering the accentuated and sustained dynamics of upgrading the level of equipment of the CNCRNC "Dr. Nicolae Robănescu", in recent years, practically all patients with CP, in addition to physical therapy, also had one or more procedures such as: "G-EO", "NIRVANA", "LOCOMAT", "HYDROTERAPIE", "MYRO", "ARMEO", "ANDAGO", "PABLO", "VIBRAMOV"; so that as a group/ control group/ effective comparison control (which only performed physical therapy), I considered this one the most appropriate.

Subsemnata Dr. Andrada Mirea, sunt de acord ca datele din grupul de control din cadrul tezei mele de doctorat, in care a fost utilizata scala "Gross Motor Function Measure" (GMFM) sa fie preluate, in scopuri comparative - de catre colegul meu drd. Radu Mihai Avram in lucrarea sa de doctorat.

09-10-2017

Dr. Andrada Mirea

Anexa nr.7. Acord de utilizare a datelor din cadrul prestigioasei Teze de Doctorat a Doamnei Conf. Dr. Andrada Mirea

Obviously, this option for establishing the group/ control group/ control represents an objective limitation of our research (and more so within this group/ control group/ control of 89 patients with CP, who only performed physiotherapy during hospitalization, only 13 patients were teenagers); on the other hand, as I have shown above, this group/batch was the only possibility of comparison between the effects of the complex therapeutic-recuperative program including interventions based on RV/augmented and the classic program that only included physical therapy, at the same time the overall size of this group/lot (89 patients with PC) being adequate for its size as statistical power.

We reiterate the fact that the inclusion in our doctoral study was made only after completing the Informed Consent, in which all the information related to the study was found, regarding: the description of the stages, patient safety, benefits, risks, volunteering,

the immediate possibility of withdrawing from the study - without negative consequences for the patient -, confidentiality, the right to continuous information by providing the contact data - personal phone number and email address of the undersigned, as a doctoral researcher.

Tabel 5.1. Prezentarea sinoptică a programelor terapeutico-recuperatorii: clasic (doar kinetoterapie) și respectiv de RV/ augmentată, în programele analizate

LOT	KINETOTERAPIE CLASICĂ	ANTRENAREA STABILITĂȚII ȘI ECHILIBRULUI – MODALITĂȚI APARATUALE MODERNE: PRO-KIN 252	MYRO	NIRVANA	G-EO	TIMP
LOT MĂRTOR/ CONTROL	30' * 2/ ^{ZI} L-V 30' * 1/ ^{ZI} S-D	- -	- -	- -	- -	60'/ ^{ZI} 30'/ ^{ZI}
LOT STUDIU I	20'	15'	10'	10'	20'	75'/ ^{ZI}
LOT STUDIU II	20'	15'	10'	15'	30'	90'/ ^{ZI}

METODE CONVENȚIONALE	OBIECTIV	EXERCITII
FNP	CREȘTEREA AMPLITUDINII ARTICULARE	RELAXARE-OPUNERE (R.O.) / "tine-relaxează" - Varianta I - pentru musculatura anteroasă/ hipertensă și Varianta II - pentru musculatura hipotensă. Izometria se face în punctul de limitare a mișcării, după ce se menține timp de 5-8 secunde la intensitate maximă, și se este apoi relaxare. RELAXARE-CONTRACTIE (R.C.) / se realizează în cazul musculaturii hipertense. La punctul de limitare a mișcării se realizează izometrie de mușchii hipertens, și concomitent izometrie de toată amplitudinea de mișcare de rotatie din articulația respectivă.
KARAT	INTINDERE MUSCULARĂ	Exercițiul din decubitus dorsal cu membrul superior deasupra capului cu abducție 90°, antebrațul nedeal - brațul în rotație externă - degetele externe și abdușe, se flexează degetele și mâna, antebrațul se suprasază - abducția brațului cu rotație internă - umărul de flexie și opoziția policelului.
KARAT	DISOCIERE MUSCULARĂ	Din decubitus dorsal brațul pacientului desce o mișcare diagonală de aruncare a unui obiect peste umărul opus urmând mișcarea: kinetoterapeutul opoziând rezistență mișcării necoordonate.
KARAT	COORDONARE MUSCULARĂ	Din decubitus dorsal pacientul execută mișcarea de jos în sus - amplitudinea este în extensie, gradat se face extensia degetelor, flexia dorsală nisior, supinația micșorului, adducția, flexia-rotatie internă a șoldului.
FRENKEL	MIȘCAREA CONTROLATĂ	Din decubitus dorsal pacientul execută mișcări de flexie/extensie sold-ateușchii, urmând cu precizie execuția, dând-se comenzi de pornire și oprire.
FRENKEL	DOBÂNDIREA ABILITĂȚII	Din decubitus dorsal pacientul duce călcânel în mușchii tibiei opuse, apoi este ridicat și așezat alături de gamba opusă urmând de extensie.
BOBATH	DOBÂNDIREA/ANTRENAREA ECHILIBRULUI	Pacientul în ortostatism pe placa de echilibru, kinetoterapeutul imprimă mișcări de lateralitate, poziția pacientului fiind schimbata după 10 repetări din anterior-posterior A.P în sensul lateral M.L.
KENNY	REEDUCARE NEUROMOTORIE	Prin mișcarea pasivă a membrului afectat/paralizat, mișcări sacadate de flexie/extensie 1/4 secunde în secundă în care se determină contracția mușchilor, pauză 5 secunde după care se reia, 10 repetări pacientul se concentrează și urmărește mișcarea.
MARGARETH RHOOD	ANTRENAREA ECHILIBRULUI	Poziția pacientului, așezat pe talpa pedes-ortostatism, kinetoterapeutul aplică presiuni la nivelul cap-umerii-sold în vederea stabilizării în poziție, kinetoterapeutul aplică mișcări moderate/intense în vederea dezechilibrării în AP -ML. DEZECHILIBRARI - cu șchi deschise/incluzi/moștea cu deusvlări.
TEHNICI MODERNE DE ABORDARE ȘI ANTRENAMENT A STABILITĂȚII ȘI ECHILIBRULUI	ANTRENAREA MUSCULATURII ABDOMINALE SUPERIOARE ȘI INFERIOARE, OBIECTI ABDOMINALI, ERECTORII SPINALI	Pacientul în ortostatism pe placa de echilibru, pacientul își deplasează centrul de presiune pe discul simple (medie-lateral/anterior-posterior) și complexe (diagonală, octogonală), marșând marșurile acestora, din poziție statică și dinamică.

Anexa nr.8. Descrierea și aplicarea kinetoterapiei clasice privind metodele și procedurile folosite

Pilot Study I

14 adolescents with PC and consecutive balance disorders were studied, to whom the "intensive" therapeutic-recuperative approach methodology was applied, and the effects on some stabilometric parameters of the application of the complex therapeutic-recuperative program based on the use of physical therapy and RV/augmented, between the specific clinical-functional status of the enrolled patients, from admission vs. the one at discharge. result

There is a correlation between the data obtained for the situation with "C.E." and the one with "O.E."; more precisely, for the areas of the ellipses obtained at admission, the Pearson correlation coefficient is 0.9587, signifying a very strong correlation, and for the areas of the

ellipses obtained at discharge, the same type of coefficient had the value of 0.7831, also signifying the correlation. The paired t-test attaches a P-value of 0.0324 to the statement "at discharge the ratio of areas obtained for "C.E." vs. "O.E." is lower than the same ratio at admission". This value is less than the threshold of 0.05, therefore the statement can be considered as statistically significant.

Study II

Study II included, as we have shown, 89 patients (of which 14 were added representing adolescents with CP and consecutive balance disorders, from the Pilot study 40 in the "moderate" group/lot, with a methodological dosing algorithm related to a total duration of recovery treatment of 75 minutes and 34 in the "intensive" group/group [of which 14 from the Pilot Study (I)]; we remind you that all patients in the two study groups/groups were teenagers, aged between 13- 18 years (156-216 months).

Working hypothesis: If these modern methods of therapeutic-restorative approach can have a positive and objectified instrumental/statistical influence - the balance function.

Result



Statistically significant differences were determined, comparing the primary, related data collected at the initial (before the beginning of the therapeutic-recovery programs) and final (at the end of the therapeutic-recovery programs) evaluations, between the results obtained through the classical therapeutic-recovery approach (in the group/batch control/control) and the complex, diversified and augmented programs, which we used in the two study groups/lots (previously presented), for most of the parameters in the evaluation scales or, respectively, the means/equipment facilities used.

Study III

Working hypothesis: as we showed in this, the third study, we aimed at the fact that by adding patients recruited in both study groups/groups we would create the possibility of obtaining (using, for evaluations, the same scales and measurements), of additional, propensity data for statistical analysis able to provide further increase in consistency and reliability for the final conclusions of our overall doctoral clinical research. We had a total

of 163 patients, if we exclude the control group/group and 252 if we include it, distributed as follows: "moderate" group/study group: 74 patients (75) "intensive" group/study group: 89 patients (90) control group/ control group (for GMFM-66 only): 89 patients.

Results:

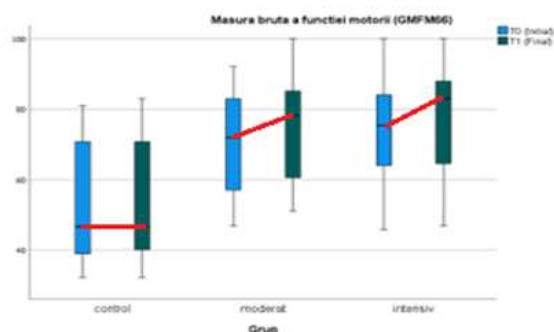


Figura 8.30. Graficul BoxPlot al scalei GMFM-66 per grup/ lot și per moment: filtrând pentru adolescenții din cadrul grupului/ lotului martor/ control

Regarding the comparison between three groups/groups analyzed by the study (the two study groups/groups and the control group/group), comparison made only for the parameter/ on the GMFM-66 scale, we found significant differences between the group/group control and each of the two study groups/lots, in their favor at both T0 and T1.

Discussions and partial (sectoral) conclusions

We will present, a little further, synthetically, in table 8.125. the three perspective comparisons, with the most important statistical values (including p-values).

Thus, in the last column, on the right, on a green background, the significant differences are marked (p-value < the 0.05 threshold; see, however, the related nuances of understanding/interpretation, presented on page 8.75.).

For an exhaustive image/representation, we have presented on a light green background those p-values close to the statistical significance threshold of 0.05.

In table 8.125, at the same time, it is marked (/written in bold) the group/lot "in favor" of which the values of the measured clinical-functional and apparatus parameters have evolved. At the same time, we treated separately the values of the parameter / on the GMFM-66 scale, because in this case the comparison was not only made between the two study groups/lots - - but between three groups/ groups of patients with CP (including the group/ control group/ control, in two variants: of 89 cases/ so with good statistical power but with the inconvenience of containing mostly children and not teenagers

– and respectively, a control/control subgroup/subgroup, detached from it and made up exclusively of teenagers, the latter therefore having the advantage of rigor compared to the study groups/groups from the point of view of age but being smaller from the point of view numeral). As such in tables 8.125. and 8,126. comparisons of independent data from one group/batch to another are presented.

In the tables (8.127. and 8.128.) we present paired comparisons performed on the same patient, but under different test conditions: from one moment (T0) to another (T1) or from the situation with O.E. to the situation with C.E.

Overall, looking from a multi-level approach perspective, both conceptual-methodological of the parameters/variables that were the subject of evaluation and from that of the measurements performed, we found, in general ("global" - see the statistical explanations of earlier) a certain superiority, as a clinical-functional therapeutic-recuperative benefit, of the "intensive" group/batch.

Tabel 8.125. Tabel de sinteză a variabilelor asociate testului Romberg efectuat aparatul pentru determinarea dinamicii, dintre situația cu O.E. și situația cu C.E. (pentru ISG, din motive de siguranță a pacientului, evaluarea se efectuează numai cu O.E.)

Teste independente (grup/lot "moderat" vs. grup/lot "intensiv")					
Variabilă	Grup/lot	Medie grup/lot "moderat"	Medie grup/lot "intensiv"	Diferența ("intensiv" - "Moderat")	p-value
Aria elipsei	O.E. la T0	910,449	1134,0313	223,582	0,122
	O.E. la T1	718,6601	664,0543	-54,606	0,421
	C.E. la T0	1731,8183	1785,8288	54,01	0,757
	C.E. la T1	1283,8428	1116,4052	-167,44	0,265
	O.E. la T0	2,1479	1,9396	-0,21	0,429
	O.E. la T1	1,9411	1,4608	-0,48	0,01
Deviația standard a trunchiului	C.E. la T0	2,4308	2,416	-0,01	0,896
	C.E. la T1	2,322	1,8106	-0,51	0,018
	O.E. la T0	14,1897	13,3298	-0,86	0,482
Viteza centrului de greutate A-P	O.E. la T1	12,5164	11,1289	-1,39	0,202
	C.E. la T0	20,6414	18,1672	-2,47	0,386
	C.E. la T1	18,3104	15,3515	-3,46	0,062
	O.E. la T0	11,285	11,2119	-0,07	0,55
Viteza centrului presiunii M-L	O.E. la T1	9,3833	8,8619	-0,52	0,546
	C.E. la T0	15,374	15,2185	-0,16	0,996
	C.E. la T1	14,3415	12,0347	-2,31	0,224
ISG	T0	3,4442	3,2702	-0,17	0,781
	T1	3,0434	2,7698	-0,27	0,403

Tabel 8.126. Teste independente grup/ lot martor/ (89 cazuri) control vs. grup/ lot "moderat"/ "intensiv"

PBS	T0	50,1905	50,9744	0,78		0,101
	T1	51,6667	52,6026	0,94		0,047

Teste independente grup/ lot martor/ control vs. grup/ lot "moderat"/ "intensiv"								
Variabila	Subgrup	Medie grup/lot control	Medie grup/lot "moderat"	Medie grup/lot "intensiv"	Diferenta ("moderat" - control)	Diferenta ("intensiv" - control)	Diferenta ("intensiv" - "moderat")	p-value (global)
GMFM66	T0	54,0212	70,6378	73,8609	16,62	19,84	3,22	<0,001
	T1	54,6120	74,2149	77,7562	19,60	23,14	3,54	0,000

Teste independente (subgrup/ subplot martor/ control vs. grup/ lot "moderat", respectiv "intensiv")								
Variabila	Subgrup / subplot	Medie subplot control/ martor	Medie grup/lot "moderat"	Medie grup/lot "intensiv"	Diferenta ("moderat" - control)	Diferenta ("intensiv" - control)	Diferenta ("intensiv" - "moderat")	p-value (global)
GMFM66	T0	53,3285	70,6378	73,8609	17,31	20,53	3,22	<0,001
	T1	53,8631	74,2149	77,7562	20,35	23,89	3,54	<0,001

Tabel 8.127. Testul eşantioanelor pereche (T0 vs. T1)

Teste-pereche (T0 vs. T1)					
Variabila	Grup/lot	Medie T0	Medie T1	Diferenta (T1 - T0)	p-value
Aria căpac	O.E. lot "moderat"	910,449	718,6601	-191,79	<0,001
	O.E. lot "intensiv"	1134,031	664,0543	-469,98	<0,001
	C.E. lot "moderat"	1731,818	1283,843	-447,98	<0,001
	C.E. lot "intensiv"	1785,829	1116,405	-669,42	<0,001
Deviația standard a trunchiului	O.E. lot "moderat"	2,1479	1,9411	-0,21	0,069
	O.E. lot "intensiv"	1,9396	1,4608	-0,48	<0,001
	C.E. lot "moderat"	2,4308	2,3220	-0,11	0,567
	C.E. lot "intensiv"	2,4160	1,8106	-0,61	<0,001
Viteza pentru mersul A-P	O.E. lot "moderat"	14,1897	12,5164	-1,67	<0,001
	O.E. lot "intensiv"	13,3298	11,1289	-2,20	<0,001
	C.E. lot "moderat"	20,6414	18,8104	-1,83	0,058
	C.E. lot "intensiv"	18,1672	15,3515	-2,82	<0,001
Viteza pentru mersul M-L	O.E. lot "moderat"	11,2850	9,3833	-1,90	0,002
	O.E. lot "intensiv"	11,2119	8,8619	-2,35	<0,001
	C.E. in lotul "moderat"	15,3740	14,3415	-1,03	0,089
	C.E. in lotul "intensiv"	15,2185	12,0347	-3,18	<0,001
PBS	Grup/lot "moderat"	50,1905	51,6667	1,48	<0,001
	Grup/lot "intensiv"	50,9744	52,6026	1,63	<0,001
ISG	Grup/lot "moderat"	3,4442	3,0434	-0,40	<0,001
	Grup/lot "intensiv"	3,2702	2,7698	-0,50	<0,001

Tabel 8.128. Teste-pereche (T0 vs. T1)

Teste-pereche (T0 vs. T1)						
Variabila	Grup/lot	Medie T0	Medie T1	Diferenta (T1 - T0)	p-value	
GMFM-66	Grup/lot control	54,0212	54,6120	0,59	<0,001	
	Grup/lot "moderat"	70,6378	74,2149	3,58	<0,001	
	Grup/lot "intensiv"	73,8609	77,7562	3,90	<0,001	

Teste-pereche (T0 vs. T1)						
Variabila	Subgrup/ subplot	Medie T0	Medie T1	Diferenta (T1 - T0)	p-value	
GMFM66	Subgrup/ subplot control	53,3285	53,8631	0,53	0,004	
	Grup/lot "moderat"	70,6378	74,2149	3,58	<0,001	
	Grup/lot "intensiv"	73,8609	77,7562	3,90	<0,001	

Table 8.130. Summary synthesis of the results obtained in studies II and III regarding the differences/recuperative clinical-therapeutic evolution between the moments: initial (T0 – before treatment) and final (T1 – after treatment) between the classic recuperative treatment (applied to the group/ control group/ control, respectively to the control

subgroup) and the one administered to the study groups

Legenda	
N.S.S. (diferențe nesemnificative statistic)	
D.S.S. (diferențe semnificative statistic)	
İ.S.S. (diferențe înalt semnificative statistic)	
Studiul II	Studiul III
Moderat / Intensiv	Moderat / Intensiv
(doar "global" nu și "individual" – v. explicațiile de tip statistic de mai înainte)	
Aria elipsei	
Aria elipsei în situația cu O.E.	
İ.S.S./İ.S.S. p<0,001	İ.S.S./İ.S.S. p<0,001
Aria elipsei în situația cu C.E.	
İ.S.S./İ.S.S. p<0,001	İ.S.S./İ.S.S. p<0,001
Deviația standard a trunchiului	
Deviația standard a trunchiului în situația cu O.E.	
N.S.S./İ.S.S. p<0,001	N.S.S./İ.S.S. p<0,001
Deviația standard a trunchiului în situația cu C.E.	
N.S.S./İ.S.S. p<0,001	N.S.S./İ.S.S. p<0,001
Viteza medie de deplasare a centrului de presiune în direcția A-P	
Viteza medie de deplasare a centrului de presiune în direcția A-P în situația cu O.E.	
D.S.S./İ.S.S. p<0,001	N.S.S./İ.S.S. p<0,001
Viteza medie de deplasare a centrului de presiune pe direcția A-P în situația cu C.E.	
N.S.S./D.S.S.	D.S.S./İ.S.S. p<0,001
Viteza medie de deplasare a centrului de presiune în direcția M-L	
Viteza medie de deplasare a centrului de presiune în direcția M-L, în situația cu O.E.	
N.S.S./D.S.S.	D.S.S./İ.S.S. p<0,001
Viteza medie de deplasare a centrului de presiune pe direcția M-L în situația cu C.E.	
N.S.S./İ.S.S. p<0,001	N.S.S./İ.S.S. p<0,001
"Indicele de stabilitate global (ISG)" bazat pe echilibrare bipodală orizontală, exprimat în grade de inclinare a platformei	
İ.S.S./İ.S.S. p<0,001	İ.S.S./İ.S.S. p<0,001
Scala de echilibru pediatric (PBS)	
İ.S.S./İ.S.S. p<0,001	İ.S.S./İ.S.S. p<0,001
GMFM-66 (grupurile/ loturile de studiu comparativ cu grupul/ lotul martor – inițial – de 89 copii și adolescenți)	
C = İ.S.S. M = İ.S.S. I = İ.S.S. p<0,001	C = İ.S.S. M = İ.S.S. I = İ.S.S. p<0,001
GMFM-66 (grupurile/ loturile de studiu comparativ cu subgrupul/ subplotul martor/ control – comparabil ca vârstă – de 13 adolescenți)	
C = D.S.S.	M/ C: İ.S.S. p<0,001
M = İ.S.S. p<0,001	I/ C: İ.S.S. p<0,001
I = İ.S.S. p<0,001	I/ M: İ.S.S. p<0,001

Concluzii și contribuții personale

Conclusions and personal contributions

1. This Doctoral Thesis addresses the problem of balance disorders in adolescents with CP from the modern perspective of the use of apparatus devices with quantified functional evaluation capabilities as well as of some related, physiatry, advanced methodologies.
2. It is known that due to the specific posture and motility: orthostatism and walking, biped - the static and dynamic balance of the body and, respectively, its positioning in conditions of sequential stability, represents a feature and at the same time a key determinant of human functioning; therefore, attempts to contribute to the correction/recovery in such disorders is a major therapeutic target and – unfortunately, still – always current given the fact that for lesions, especially severe ones of the CNS, such as those in CP are not at least there is healing for now.
3. Under these conditions, I had the opportunity to use and objective the contribution/contributive/evaluative and therapeutic-recovery performances of advanced devices and methodologies in addressing the above-mentioned disorders, taking into account the remarkable level of endowment - at international standards – of the clinical unit where I carry out my activity.

4. I specify, from this point of view, on the one hand the fact that CNCRNC "Dr. N. Robănescu" is the first unit in our country that was equipped with the Pro-kin 252 device and on the other hand, the fact that in the literature - to our knowledge (we also mention here that, in preparation for the realization of this doctoral study, we also established a fund of theoretical knowledge, we consider adequate, based on a systematic literature review, related) - we did not find any works focused on this population target: adolescents with CP and consecutive balance disorders, with their evaluative and therapeutic-recovery approach, in a physiatry complex multiplanar, including using advanced physical therapy devices and especially in association with RV/augmented procedures.

5. Concretely, this doctoral work is the result of my direct experience of about 7 years in the use of apparatus devices and related, physiatry, evaluation and advanced therapeutic-recovery methodologies, including in the approach of balance disorders in standing and walking, consecutive PC; more precisely, in this Doctoral Thesis I used: Pro-KIN 252, G-eo Evolution - in association with immersive RV - Myro and Nirvana (RA) (interventions associated, within standardized complex programs, of classic kinesitherapy procedures/conventional).

6. As it was shown in detail in this doctoral work, we objectified and measured a consistent number of clinical-functional parameters contributing to the assessment of balance disorders in standing and walking, namely five through instrumental determinations and two through clinical-functional quantification scales namely: 1. "Area of the ellipse" (in mm²), 2. "Standard deviation of the trunk" (in degrees), 3. "Average speed of movement of the center of pressure in the A-P direction" - in mm/s), 4. "Average displacement speed of the center of pressure in the M-L direction" (in - mm/s), 5. "Global stability index" (ISG - in degrees of platform inclination), respectively the non-apparatus tests, digitally compatible for processing statistics 6. "Pediatric Balance Scale (PBS)" and 7. "Gross Motor Function Measure (GMFM-66)".

7. The determinations listed above also allowed us to objectify/measure the elements of therapeutic-recuperative benefit obtained by applying two dosage schemes, in terms of duration, used by RV/augmented: "moderate" and respectively "intensive" (in an interventional context multiplanar physiatric), which we applied to adolescents with CP and consecutive balance disorders in the groups/groups with the corresponding names ("moderate" group/group vs. the "intensive" group/group).

8. Thus based including on a complex analysis/statistical processing methodology, we found that the patients from the two study groups/groups had, post-intervention (T1 vs. T0), significantly statistically superior results compared to both the group/group control/control as well as compared to the control/control subgroup/subgroup and respectively those from the "intensive" group/group had, ("only global" but not "individual" - see the detailed explanations in study III of this Thesis Doctorate), statistically significantly better results than those in the "moderate" group/batch.

9. We recall for the sake of rigor, the fact that, from the aspect of clinical-functional reasoning, within the measured Romberg-type parameters, the results in the practice of medical-recuperative assistance are quite difficult to observe non-apparatus, but this reality can also be understood as a higher quality element of the use of advanced specific equipment.

11. Also, a possible limitation of the present research carried out/ in the elaboration of this Doctoral Thesis, is (in addition to the mixed composition: children plus adolescents of the group/ control group/ control in its entirety and, respectively, the smaller number of cases of the patient component adolescents from the control/control subgroup/subgroup) the options expressed by the respective parents regarding voluntary inclusion in the "moderate" or "intensive" group/group, taking into account aspects of balance (at the same time with subjective elements) between the desire/trust – of principle, natural - and the psychological "investment" in a procedural complex with a more pronounced profile and, respectively, the concern for a potential risk of additional patient fatigue (by the way, due to the ethical precaution of our research, we chose to carry out the clinical studies related to our work doctoral studies on adolescents (not children) with CP and consecutive balance disorders considering the therapeutic-recuperative component of immersive VR.

12. So, the dosage, in the end, between the "moderate" and "intensive" forms - has no statistically significant differences (of the "individual" type - according to what is explained in the Thesis), which is not unimportant because we allows in the future to adapt to the preferences of teenagers, their relatives and administrative conditions (work schedule/stay period).

13. Both the methodology of analysis/statistical processing (rigorous and complex) and the statistical power of the groups/batches of patients evaluated allowed us to draw valid conclusions - consolidated even in the conditions of the dynamics of the statistical power of

the groups/batches - and therefore permissive for the practical use of methodological conclusions, of applied dosage for our current profile activity.

14. The fact that apart from translational - at the level of research and current assistance - these technologies should become known to the entire recovery department, provided as a tool in the therapeutic-recovery arsenal, regarding the recovery of balance disorders in PC (and not only) – as a continuation of this research on modern/present multimodal modalities – by adding more RV/augmented interventions and treatment/recovery apparatus systems.

15. Regarding the technical and economic advantages and disadvantages related to this doctoral scientific research endeavor, I had the beneficial opportunity to be able to use advanced recuperative assessment and treatment devices and technologies - a mechatronic stabilometric device entered for the first time in the equipment of a medical-sanitary unit in the country ours – adding to this a number of RV/augmented devices and facilities, also modern and not yet very common in our profile units; obviously, any new and especially advanced technology involves the "disadvantage" of some sometimes more substantial costs, on the other hand, obtaining superior therapeutic-recovery results is linked, as a principle, to advances in related interventional devices and technologies - and from this point of view, as I have shown in this Thesis, a good part of the postural, dynamic improvements could be objectified with apparatus, but being difficult to observe "with the naked eye" (non-apparatus).

16. The results obtained constitute, we consider, a personal contribution to the objectification of the knowledge and interventional, theoretical and practical base - thus the objectives of our doctoral clinical study have been achieved.

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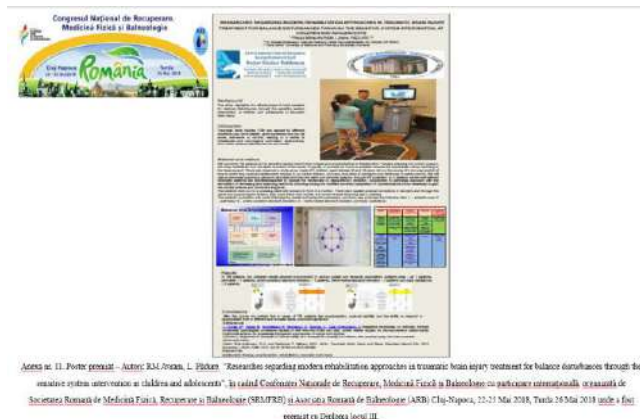
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