„CAROL DAVILA” UNIVERSITY OF MEDICINE AND PHARMACY,
BUCHAREST, DOCTORAL SCHOOL
FIELD: MEDICINE

PERSONALIZED NEUROREHABILITATION IN THE DIGITAL MEDICINE ERA: INTERDISCIPLINARY APPROACHES FROM BIOTECHNOLOGY TO ARTIFICIAL INTELLIGENCE

ABSTRACT OF THE HABILITATION THESIS

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This work, entitled “Modern Neurorehabilitation: Integration of Digital Technologies, Non-Pharmacological Therapies, and Personalized Medicine in Post-Stroke, Post-TBI, and Neurodegenerative Disease Recovery”, synthesizes my professional, academic, and scientific experience accumulated in the field of Rehabilitation, Physical and Balneological Medicine, with an emphasis on the interdisciplinary approach and the integration of technological innovations into modern clinical practice. The work is structured into five chapters, each reflecting the main dimensions of my career: scientific activity, academic activity, professional experience, involvement in national and international projects, and future development directions.

Introduction and Context

In recent decades, neurorehabilitation has undergone a significant transformation, driven by advances in neuroscience, functional imaging, artificial intelligence, robotics, and assistive technologies. From the status of a complementary discipline, it has become a central specialty of contemporary medicine, in response to the increasing prevalence of neurological conditions with disabling potential, such as stroke (CVA), traumatic brain injury (TBI), neurodegenerative diseases, and spinal cord injury. The rising prevalence of neurological conditions with disabling potential has necessitated the development of a strategic domain capable of responding through scientifically validated interventions, interdisciplinary collaboration, and the use of advanced digital technologies.

Objectives of the Habilitation Thesis

This thesis aims to consolidate and present my academic, clinical, and research experience in the field of neurorehabilitation, capitalizing on the results obtained in medical practice, university teaching, and applied research. A primary objective is the synthesis and critical evaluation of scientific contributions, with a focus on innovative post-doctoral projects such as STRATIF-AI and BIOHIS, highlighting their impact on understanding neurorehabilitation mechanisms and implementing personalized digital medicine. In this regard, original contributions in interdisciplinary research are presented, integrating artificial intelligence, hyperspectral imaging, and objective assessment tools such as the Fugl-Meyer Assessment.

Another objective is to demonstrate scientific leadership through active participation in international consortia, coordination of projects, and publication of articles in ISI-indexed specialty journals with visibility and impact in the field. The thesis also aims to illustrate teaching and mentorship expertise, by presenting innovative teaching methods, contributions to the university curriculum, and an active role in training young specialists, especially in the areas of digital medicine and neurorehabilitation.

An essential objective is to highlight the role of non-pharmacological therapies and integrative interventions—such as balneotherapy, neuromodulation, and multimodal programs—in optimizing functions and supporting the recovery process, with an emphasis on translating research results into concrete clinical solutions for the management of patients with stroke, TBI, and other neurological conditions.

The thesis also advocates for the development of translational research platforms that correlate biological and imaging biomarkers with clinical and functional data, to facilitate the definition of personalized recovery trajectories. In this context, it documents involvement in European and national projects, detailing contributions, results, and their impact on the field.

Last but not least, the work outlines a strategic development plan aimed at consolidating a national and international research network in digital neurorehabilitation, expanding academic collaborations, developing innovative projects, and creating a Center of Excellence in Digital Neurorehabilitation at the "Carol Davila" University of Medicine and Pharmacy. This plan is conceived as realistic and sustainable, oriented towards improving research quality, disseminating results internationally, and implementing them in clinical practice.

Professional and Academic Trajectory

My career, carried out for more than fifteen years within the "Bagdasar-Arseni" Clinical Emergency Hospital and the "Carol Davila" University of Medicine and Pharmacy in Bucharest, in the specialty of Rehabilitation, Physical and Balneological Medicine, combines clinical activity—focused on patients with complex central and peripheral neurological conditions (post-stroke, post-TBI, spinal cord injuries, neurodegenerative diseases), as well as rheumatological, oncological, or orthopedic pathology—with academic activity, where I have developed and implemented educational programs for students, residents, and doctoral candidates, as well as active involvement in scientific societies and in the organization of congresses and professional events. Internationally, collaboration within prestigious consortia has facilitated the development of functional classification algorithms and predictive models applicable directly to medical practice.

The scientific activity carried out so far reflects a constant evolution from the topic of my doctoral thesis, centered on the management of severe traumatic brain injury, towards a complex approach to central and peripheral neurological conditions, with an emphasis on post-stroke recovery and digitally assisted personalized medicine. In this journey, I have constantly aimed to integrate fundamental research with clinical applicability, developing and validating assessment tools, therapeutic protocols, and innovative digital solutions. Significant contributions include the validation of the Romanian version of the Fugl-Meyer Assessment,

used internationally for the standardized evaluation of motor function in post-stroke patients; clinical studies on the use of Actovegin in subacute TBI, with positive results on functional and cognitive recovery; as well as involvement in projects focused on post-stroke cellular and molecular mechanisms, targeting therapeutic pathways such as transcriptional regulation (STAT3, CREB), neurovascular inflammation, microglial activation, and blood–brain barrier protection. I have also participated in the evaluation of the neuroprotective potential of lithium in ischemic stroke—through reducing cerebral edema, activating Wnt/β-catenin signaling, and inhibiting GSK3β—and in promoting innovative non-invasive interventions such as photobiomodulation, transcranial stimulation, and hyperbaric oxygen therapy, in the context of personalized recovery.

A significant part of my scientific activity has been dedicated to integrating emerging technologies into neurorehabilitation. Within the European STRATIF-AI project, I participated in the development of a digital twin model based on artificial intelligence, capable of integrating clinical, functional, imaging, and genetic data to predict and optimize the recovery pathway of stroke patients. In parallel, in the national BIOHIS project, I applied hyperspectral imaging to assess microcirculatory changes and correlate them with clinical evolution. My research has also included the analysis of the effects of mineral waters and sapropelic mud on cardiovascular and neuromuscular parameters, confirming the value of balneotherapy integrated into complex recovery programs. In the field of neurodegenerative diseases, I contributed to systematic reviews on non-pharmacological interventions in Alzheimer's disease, based on mechanisms of neuroplasticity and neuroinflammation.

Academic Activity

My academic activity has taken place within the "Carol Davila" University of Medicine and Pharmacy, where, as a university faculty member, I have delivered courses and clinical training for students, residents, and doctoral candidates, coordinating numerous applied research projects. I have developed educational content tailored to the training needs of future specialists in recovery, focusing on understanding neurophysiological mechanisms, applying modern assessment methods, and integrating digital tools into medical practice. The academic activity has been complemented by involvement in organizing national and international scientific events, conferences, and workshops, contributing to the continuous training of specialists in the field.

Professional Experience

The professional experience accumulated at the "Bagdasar-Arseni" Clinical Emergency Hospital has included both direct clinical activity and responsibilities for coordinating and

implementing therapeutic protocols. I have been involved in developing and applying personalized recovery programs for patients with stroke, TBI, spinal cord injuries, and other neurological and orthopedic conditions, collaborating interdisciplinarily with specialists in neurology, neurosurgery, imaging, cardiology, and internal medicine. This multidisciplinary framework has allowed adaptation of interventions to the specific needs of each patient and evaluation of progress based on objective parameters.

Internationally, my involvement in projects such as STRATIF-AI, BIOHIS, and COST Action CA24123 has facilitated collaboration with European centers of excellence and access to advanced research infrastructures. These partnerships have enabled the development of algorithms for functional classification and the validation of non-invasive biomarkers, contributing to the foundation of predictive models for recovery.

Future Development Directions

Future development directions aim to strengthen applied research in neurorehabilitation and expand expertise in digital medical technologies. I plan to create a Center of Excellence in Digital Neurorehabilitation at the "Carol Davila" University of Medicine and Pharmacy, which will integrate artificial intelligence, biosignal analysis, robotics, and telemedicine into the personalized approach to the patient. I will also continue to develop digital educational platforms for training specialists in recovery, expand international collaborations, and contribute to defining precision recovery protocols correlated with clinical and imaging biomarkers.

Conclusion

This work reflects a professional and scientific activity built on an integrated, translational vision, where fundamental research, clinical practice, and technological innovation converge to address the current challenges of neurorehabilitation. The contributions made define a path oriented towards excellence and support the transition from traditional recovery models to personalized, digital, and evidence-based medicine. This habilitation thesis documents a career dedicated to modern neurorehabilitation, in which the constant interaction between clinical practice, technological innovation, and academic leadership has resulted in a significant impact on patients and on the development of rehabilitation medicine in Romania and internationally.

As the completion of this habilitation thesis represents a moment of evaluation of the results obtained, I would also like to express my profound respect and gratitude to Professor Gelu Onose, whose guidance and mentorship have been invaluable throughout my academic and professional journey.