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INTERDISCIPLINARY CONTRIBUTIONS IN BIOMECHANICS, FUNCTIONAL REHABILITATION AND PHYSIOTHERAPY FOR PEDIATRIC SPINE DISORDERS AND JOINT TRAUMATOLOGY

ABSTRACT OF HABILITATION THESIS

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Abstract of Habilitation Thesis

The habilitation thesis entitled INTERDISCIPLINARY CONTRIBUTIONS IN BIOMECHANICS, FUNCTIONAL REHABILITATION AND PHYSIOTHERAPY FOR PEDIATRIC SPINE DISORDERS AND JOINT TRAUMATOLOGY presents the activity carried out in the research, academic and teaching plan since 2012, the year in which I defended my doctoral thesis in the field of sports and physiotherapy, in the field of Physical Education and Sport, with the title ETIOPATHOGENESIS OF SPINE DEPOSTURATIONS IN SCHEUERMANN'S DISEASE.

The first part of the habilitation thesis presents the main academic, professional and scientific achievements of the last 14 years, being divided into four chapters according to the directions in which relevant contributions have been made.

The first chapter describes in detail the professional, academic and scientific achievements since the year of obtaining the doctoral degree, in 2012.

The second chapter presents the participation in scientific events, scientific research projects and two major research themes:

1. an integrated analysis of orthopedic implants used in tibial plateau fractures, combining experimental biomechanical studies and modern artificial intelligence methods with functional recovery strategies through physiotherapy,

2. a study highlighting the need and importance of practicing physical exercises and sports in maintaining health "Incidence and peculiarities of spinal deficiencies in children with special needs. Implications for functional rehabilitation"

Initially, in the first major research theme, the clinical context and motivation of the study are described, highlighting the importance of mechanical stability and early mobilization in complex Schatzker V type fractures. Traditional biomechanical studies are limited in evaluating complex nonlinear relationships, which determined the integration of artificial neural networks (ANN) and SVM classification for predictive modeling of implant behavior.

The objectives of the research aimed to compare the stiffness and deformation of three types of stabilization systems, namely the classic internal plate, the Locking Plate System (PLS) and the hybrid external fixator (HEF), as well as to evaluate the usefulness of the AI method in data interpretation.

The methodology included:

- use of a standardized artificial bone model (Synbone™ 1110) with simulated tibial plateau fracture;

- application of osteosynthesis systems according to standard techniques;

- progressive axial compression tests between 1300–3150 N;

- measurement of implant deformation and data analysis using ANN and SVM.

The results showed:

- the classic plate presents the highest deformation;

- PLS offers superior stiffness at low and medium loads;

- the hybrid external fixator has stable behavior, close to PLS at high loads;

- AI methods allowed for predictive evaluation and precise classification of biomechanical performance.

The clinical implications highlight that PLS and HEF implants allow for early mobilization and safer and faster functional recovery.

Recovery phases through postoperative physiotherapy (0–6 months and 6–12 months reintegration into activity) are detailed, adapted to the type of implant and biomechanical stability, including passive, active, isometric, proprioceptive and functional reintegration exercises.

Finally, the first major research theme proposes research and innovation directions, focused on:

- correlation of biomechanical parameters with physiotherapy protocols;

- development of predictive AI models for recovery planning;

- integration of dynamic testing with simulated exercises;

- creation of interdisciplinary orthopedist–physiotherapist guides and digital platforms for monitoring functional progress.

Thus, the research theme demonstrates a complete translational vision, in which experimental biomechanics, artificial intelligence and physiotherapy are integrated to optimize the treatment and recovery of patients with tibial plateau fractures.

The second major research theme highlights an increased prevalence of spinal deficiencies and postural disorders in children with SEN, compared to the values reported in the general school population, highlighting the need for systematic monitoring of the development of the locomotor system. There are three main research directions spinal pathology in children and adolescents, functional rehabilitation through physical exercise for vulnerable populations (CES, motor disabilities).

The results support the implementation of individualized kinetoprophylaxis and physiotherapy programs in the educational environment, to prevent the worsening of postural imbalances and improve the physical functionality of these children.

The second part of the habilitation thesis presents the career development plan based on the analysis of personal achievements in the academic, teaching and research fields, specifying the complex goals and strategies for short, medium and long-term achievement to optimize the professional level and contribute to the development of research and academic performance in the field of physical education, sports and physiotherapy.

The third part contains the bibliographical sources used in the habilitation thesis.