SUBMISSION FORM OF PROPOSALS FOR DOCTORAL RESEARCH PROJECTS

Objective of the Doctoral Programme in Health Sciences and Technologies

The objective of the new interdepartmental Doctoral Programme in Health Sciences and Technologies is to train the next generation of leaders in industrial, clinical, and academic research. Our goal is to develop an organic research programme at the interface between engineering and medicine, which is inspired by the quantitative and integrative approach of physical sciences, and by the latest development in biomedical research, drive the development and clinical translation of disruptive health technologies.
The doctoral training programme will prepare students in conducting research which:
- Extend the comprehension of how human physiology and pathology work in term of physical and chemical mechanisms, and how these mechanisms respond when perturbed by external factors such as therapies, changes in life style, and environmental factors;
- Develop new technologies that by leveraging on this mechanistic understanding pursue a wide spectrum of applications relevant to human health, including prevention, diagnosis, prognosis, treatment, and rehabilitation.

Procedural aspects on the submission of proposals for doctoral research projects

Every year the PhD process will start with the submission of proposals for doctoral research projects. Each proposal must be submitted jointly by two supervisors, one providing the clinical expertise, the other the technological expertise. The Project Selection Committee will select a number of projects that is twice the number of available scholarships and should be distributed in similar proportion between medical-led or technology-led proposals. The resulting list of projects will be included in the call for student applications that the Executive Committee will compile soon after. Each student, depending on their degree, will be able to apply only for a sub-set of projects; among them each student will be allowed to select three projects, and name them in order of preference; however, in some cases it might not be possible to satisfy all requests, and some students might be offered a research project different from those they selected.

Doctoral training program

In order to be admitted to the selection, a student needs a five-year higher education degree, which includes at least one module for each of the following disciplines: mathematics, physics, computer science, biology, physiology, and anatomy.

Max number of proposals for each member of the Academic Board: 3 (three)
Max number of selected projects for each member of the Academic Board: 2 (two)

Title of the project

Effect of pathological pelvic version on the risk of impingement or dislocation in total hip replacement patients

Student's degree (you can choose more than one, if needed)

Yes/Not	Cultural area
YES	Medicine, biology, or related disciplines
NO	Engineering, physics, mathematics, computer science, chemistry, materials science or related disciplines

Student's skills (you can fill more than one field, if needed)

Cultural area	Skills
Medicine, biology, or related disciplines	Training in Orthopaedic and Trauma surgery. Excellent understanding of musculoskeletal anatomy and pathology. Scientific interest and previous scientific knowledge in spinal and hip disease and surgery. Clinical experience in spinal and hip surgery.
Engineering, physics,	

mathematics, computer science, chemistry, materials science or related disciplines	

Tutors (2 from the Academic Board and from different cultural areas)

Cultural area	Name & Surname	Department
Medicine, biology, or related disciplines	Prof Cesare Faldini	DIBINEM
Engineering, physics, mathematics, computer science, chemistry, materials science or related disciplines	Prof Marco Viceconti	DIN

Research project

	Synthetic description
Summary (max 1000 chars)	A growing number of patients who received a total hip replacement, develop before or after this hip surgery a pathological version of the pelvis. This might be due to vertebral surgery, postural compensation for the spine pathology, etc. Orthopaedic surgeons share anecdotal reports of higher incidence of complications related to the hip range of motion in these patients, but no systematic study has been conducted so far. In this project the candidate will access a large body of outcome data in the RIPO registry, which combined with detailed clinical records of patients treated in the clinical department led by Prof Faldini at the Rizzoli Institute will provide a first robust evidence of such increased risk in this patients' sub-population. The candidate will then use a CT-based hip surgery simulator developed at the Rizzoli's Medical Technology Lab to estimate the so-called "safe zone" per acetabular orientation as a function of the pelvic orientation. Last, but not least a prospective study will be conducted on a small group of patients to be recruited in Prof Faldini department. The main outcome of this project will be a clinical recommendation for stratification.
Objectives (max 1000 chars)	1) Determination on retrospective cohorts of the correlation between risk of retrieval because of impingement or dislocation and abnormal pelvic orientation; 2) Definition of the change in the safe zone for acetabular orientation as function of the pelvis orientation, using a surgical simulator; 3) Design and execution of a prospective study aimed to validate a new stratification recommendation for patients with altered pelvic orientation.
Rationale and scientific background (max 2000 chars)	Of 13.823 total hip replacement that failed in our region in the last 16 years and that were recorded by the RIPO registry, almost 10% fail due to recurrent dislocation, which is the second cause of failure after aseptic loosening; however, there are evidences that some of the aseptic loosening of the acetabular component (32% of all failures) are associated to recurrent impingement, even without full dislocation. Even in patients whose implant is not revised an undetermined percentage experience more or less severe functional limitations due to insufficient range of motion of the implant. Thus, this is an important complication form a clinical point of view. Angular mispositioning of the acetabular component is one of the most common surgical errors during total hip replacement. This is due to the difficulty of properly referencing the position of the pelvis intra-operatively, but also because it is difficult to predict from the supine position the femoral-pelvic angle in the standing posture. In normal healthy people the average pelvic rotation from supine to standing can be predicted, but in patients who have a pathological version of the pelvis such prediction is impossible. There are anecdotical evidences that in such patients the risk

	of impingement and dislocation are higher, but. In authors' knowledge, no systematic investigation on this subject has been conducted so far. If we could identify in advance for these patients the so-called "safe zone" of acetabular orientation as a function of the degree of pathological pelvic version, much more specific guidelines for optimal hip replacement could be provided for this important sub-population. Prof Viceconti team has been developing the CT-based 3D HipOp pre-operative planning software since early 2000 (Lattanzi, 2002). Since 2004 HipOp provides an anatomo-functional simulation tool that computes the post-operative skeletal range of motion as a function of the planned orientation of prosthetic components.
Preliminary results if existing (max 1000 chars)	(Bedard 2016) reports that in 15 patients with spinopelvic fusion and total hip replacement the incidence of dislocation is 20%, much higher than the rest of their hip replacement cohort. In a more substantial study (Buckland 2017) on nearly 15.000 patients with spinal fusion and hip replacement found a dislocation incidence doubled when compared to the control group with only hip replacement. In authors' knowledge the only paper that look specifically at the problem is (Ike 2018); however, the revised safe zone proposed is based on mere anatomical considerations conducted on 2D radiographic images. Because of the complexity involved we believe only a full 3D anatomo-functional study can reliably explore the effect of pelvic version on the risk of impingement. Recently (Viceconti 2019) developed techniques to explore soft tissue balancing in knee replacement; the team is currently exploring the adaptation of this approach to generalise the HipOp range-of-motion simulation.
Research project including methodology (max 5000 chars)	1. Identification of the regional intervention codes associated to possible alterations of pelvic orientation 2. Statistical study on the RIPO database on the correlation between risk of dislocation and alterations of pelvic orientation; if such general association based on the intervention codes does not emerge, retrieve all patients operated in Prof Faldini division and evaluate the actual pelvic version from radiographic images. If no correlation emerges in any of these cohorts, reposition the PhD project (based on the available literature this seems extremely unlikely). 3. Write clinical trial plan and submit for approval to the Rizzoli ethical committee. 4. Extract from the retrospective database of the HipOp system (over 3000 patients) 5-10 cases with normal pelvic orientation. 5. Conduct for each patient extracted a systematic anatomo-fuctional analysis of the skeletal range of motion as a function of the acetabular orientation and of the pelvic version; conduct a power analysis on the results and add more patients if necessary. At the end of this study we would have a definition of the acetabular safe zone (against skeletal impingement) as a function of pelvic-femoral angle in standing posture. 6. Enrol a small cohort of patients in Prof Faldini and Prof Traina divisions, measure intra-operatively preoperative and postoperative range of motion, use post-operative CT to calculate the actual implant orientation, conduct HipOp planning, predict range of motion and validate with intraoperative measurements. 7. If new Range-of-Motion simulator that includes soft tissues becomes available repeat study in #5. 8. Develop radiographic or anatomical landmark palpation pre-operative protocol to quantify pelvic version and calculate form it the safe zone for that patient. The protocol will be validated in collaboration with Prof Mazzà team in Sheffield, where an EOS 3D imaging system is available, which can provide very accurate 3D quantification of the pelvic-femoral angle.
Innovation potential (scientific and/or technological) (max 1000 chars)	Deeper understanding of the anatomic and function of the role of the pelvic-femoral orientation in the pre-operative and post-operative range of motion of the hip joint. As recurrent impingement is also suspected to be a possible initiator of osteoarthritis, this project would open a would new territory of research. Validation of the Range-of-Motion prediction using intraoperative measurements would expand the scope of this tool to a variety of other cases where the risk of dislocation is higher than usual.

Expected results and applications to human pathology and therapy (max 1000 chars)	If the project is successful a new guideline for the total hip replacement of patients with altered pelvic version would be developed, which would alter the standard of care in Italy.

Available resources for the project

	Synthetic description
Research environment (involved labs and location)	The candidate would access the clinical divisions of Prof Faldini and Prof Traina, and the Laboratory of Medical Technology, all located at the Rizzoli Institute.
Main equipment (facilities and location)	Access to RIPO database under the supervision of the RIPO staff. Access to surgical planning work station with HipOp software. Access to selected cases in the retrospective HipOp database.
Additional funding (title, amount, start date, duration)	None.

International collaborations for the project (also in view of the Student's secondment)

	Project	**Location and team**
#1	Evaluation of the pelvic orientation using EOS 3D imaging system and with anatomical landmark palpation	Insigneo Institute, University of Sheffield (UK) – Prof Claudia Mazzà