seedEP2 : INTEGRATED MODELLING OF THE MUSCULOSKELETAL SYSTEM

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Introduction

Musculoskeletal modelling (MSM) showed major recent theoretical progresses including optimisation and prediction algorithms, and improved data visualisation. Despite these efforts, practical applications in daily Clinics remain rare because of a lack of extensive clinical validation. Integration of MSM tools to better understand complex pathologies also remains a challenge. This paper reports the results of a running effort of integration of MSM tools within a larger pipeline for the data handling of spasticity patients. This work include the development of modelling and ontology tools available from the VPH-NoE toolkit, with further integration of data into a clinical interpretation pipeline based in data mining performed by the ICT4Rehab project (www.ict4rehab.org/users).

Methods

The project focuses on the development of an integrated system organised around several tools (Fig. 1): - database allowing sharing of clinical data (anamnesis, clinical testing and functional data), - biomechanical analysis (including MSM), - functional ontology development, - and data mining. As such, MSM is not the unique tool available from the overall pipeline. Indeed, while it is clear that MSM is useful as a supplementary source of patient's physiological parameters next to the "usual" clinical testing, it however cannot answer all questions arising from the handling of severe disorders such as spasticity.

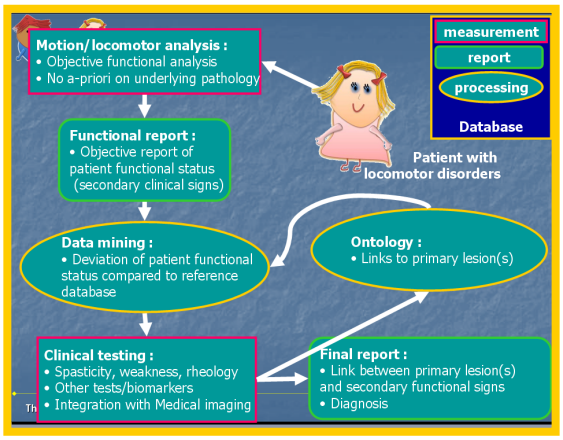

Figure 1. MSM analysis pipeline. MSM analysis (related to the motion/locomotor box) is integrated in a wider processing pipeline. Statistical data mining analysis and ontological links will allow finding the relationships between observable secondary clinical signs and the primary functional lesions.

The above-described pipeline is under development in collaboration with several clinical centres that are closely involved in the project development thanks to an active communication channel. From an MSM perspective, models integrated in the analysis pipeline (Fig. 2) could appear simplistic compared to the literature in the MSM field. The developed models are limited to the study of joint amplitude, muscle excursion and muscle moment arms. On the other hand, such MSM modelling is easily understood by

clinicians, and can be validated, for example using medical imaging. Model customization is also of importance.

Results

Although the project has recently started, results are promising at various levels. Even if it is not fully deployed yet, the entire clinical pipeline is now fully defined: - clinical data are stored in the database; - clinical data can be analyzed using modelling tools and biomechanical analysis; - and results are further analyzed in advanced data mining modules to produce biomarkers that are relevant for clinical interpretation thanks to the available functional ontology (Fig. 3). The components of the pipeline are currently being integrated and will be fully deployed in the coming year.

Discussion

In contrast to an isolated MSM tool that gives numerous, but often not properly validated results, we believe that the integrated approach taken by the seedEP2 and ICT4Rehab projects, focusing on the integration of MSM methods with complementary clinical tools, will be more attractive for clinicians. The project has therefore adopted as its main strategy to respect the daily work habits of clinicians by integrating their professional habits in a new work pipeline that is complemented by new and more advanced analysis tools. We believe that this is crucial for clinical acceptance.

Acknowledgments

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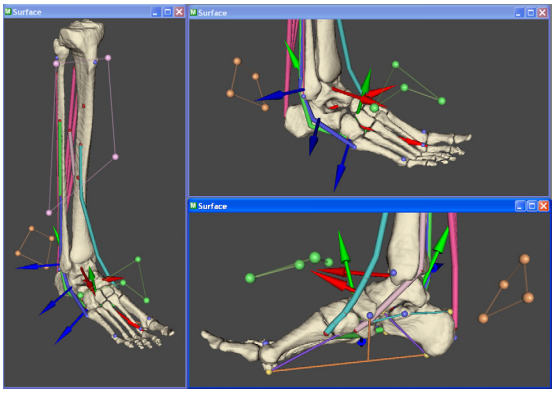

Figure 2. MSM models. This kind of model is entirely customisable and includes morphological, functional and biomechanical information that can be integrated into, for example, an analysis report. Modelling tools are available from the VPH-NoE toolkit.

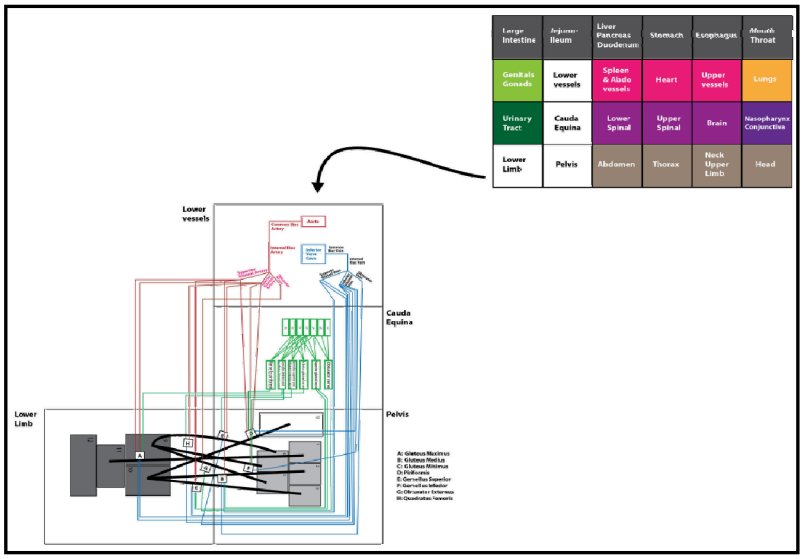

Figure 3. SeedEP2 musculoskeletal ontology of the lower limbs. This kind of functional representation includes links between any particular anatomical systems with other systems. Here, this image shows a schematic representation of the thigh including all bones, muscles and relationships with the vascular (arteries and veins) and the nervous systems. Such description allows finding relationships between for example a muscle dysfunction and the related medullar levels. [*details on this ontology work is presented in another paper during the VPH2012 Congress.*]