Università degli Studi di Verona
Graduate School of Translational Biomedicine

MUSCLE MECHANICAL WORK IN WALKER-ASSISTED LOCOMOTION: INSTRUMENTATION AND MODELLING FOR AN INTEGRATED GAIT ANALYSIS IN CEREBRAL PALSY

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“A child’s education starts with a well-estabilished knowledge (e.g. 2 x 2 = 4) and fairly tales. The fairly tales always end happly. When a student enters a college, the same principle pertains: the student studies well-estabilished knowledge. Fairly tales for students also exist: they are called “problems”in the textbooks. Textbook problems contain all the necessary information and are always solvable. Science is different. Many problems cannot be solved bacause the necessary information is not available; some problems are not solvable at all. Still, it is important to understand the problem and the difficulties associated with its solution.”

(Vladimir Zatsiorsky, *“Kinetics of Human Motion”, Chap. 6*)

Muscle mechanical work in walker-assisted locomotion: Instrumentation and modelling for an integrated gait analysis in cerebral palsy

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Abstract

The estimation of muscle mechanical work can be useful to assess movement efficiency, but it is still a challenging task in biomechanics. Different methods to estimate muscle work during walking have been presented in the literature and, although attempts have been made to investigate differences among them, all methods are still used in research and clinical applications. A deeper understanding of theoretical differences and analogies would allow to know what is exactly computed by each method and help to make a more appropriate use of this information. To this purpose, a 16 segments full-body 3D model was validated and used to collect kinematic and kinetic data from healthy children and cerebral palsy (CP) children walking at self-selected speed. Two instrumented handles fixable on the frame of posterior paediatric walkers were also developed, to measure upper limb kinetics in subjects with more severe walking impairements. Whole-body muscle mechanical power curves and work values, either *positive*, *negative* or *net*, during normal gait and during walker locomotion were obtained, demonstrating that all methods are equivalent when energy transfers between segments are allowed. With no transfers allowed, methods differ among each other, with differences depending on the movements and the methods considered. Apart from some critical issues evidenced and discussed, the analysis of whole-body muscle mechanical power curves and work estimates can provide valuable information on the overall locomotion function, highlighting propulsive deficits, gait asymmetries, movement inefficiencies associated to reduced energy recuperation.

Declaration

The work presented in this thesis is based on research carried out at:

- the Biomechanics Laboratory, University of Verona, Italy
- the Machine Design Laboratory, University of Padova, Italy
- the Oxford Gait Laboratory, Nuffield Orthopaedic Centre, Oxford, UK
- the Gait Analysis Laboratory, San Bassiano Hospital, Bassano del Grappa, Italy

No part of this thesis has been submitted elsewhere for any other degree or qualification and it is all my own work unless referenced to the contrary in the text.

My visit at the University of Oxford and at the Oxford Gait Lab was supported through the grant *Cooperint 2010* by the University of Verona. Instrumented handles have been realized with the financial support of Fondazione Cariverona and tested on walkers kindly provided by Fumagalli srl (Como, Italy).

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