

Topic: Energy Cost of Walking with a Three Dimensional Musculoskeletal Model

Metabolic energy is the energy expended by the muscles during movement. This is an important parameter in gait analysis, because energy is minimized in gait (e.g. [1]). Metabolic energy expenditure can be determined from measurements of the amount of oxygen inhaled and carbon dioxide exhaled. It can also be determined based on gait parameter such as joint angles, joint moments, and muscle forces using so-call metabolic energy models. Different metabolic energy models exist. However, they are not validated extensively against experimental recordings of metabolic energy expenditure. Previously, an approach using a two dimensional musculoskeletal model was used, but then the metabolic cost was greatly underestimated [2].

Therefore, we aim to investigate the cause of this underestimation. One possible cause is the simplification following from the two-dimensional approach. For example, a smaller number of muscles is modelled in this approach. Also, this approach does not account for the work that is performed in the frontal and transverse plane, e.g. to shift the body weight from one side to the other during stance.

The goal of this project is to understand the effect of the dimensionality of the model used in experimental processing. Metabolic energy expenditure will be calculated using a three dimensional modelling approach from available experimental data. Inverse kinematics, inverse dynamics, and a dynamic optimization should be used to determine the input variables for the metabolic energy models. The results will be compared against whole-body metabolic cost measurements and against the results obtained with the two dimensional approach. Finally, a sensitivity analysis will be performed to see how different modelling parameters affect the results.

The proposed work consists of the following parts:

- Three dimensional data processing of a gait analysis experiment.
- Design of an appropriate three dimensional muscle system
- Calculation and analysis of metabolic energy expenditure
- Comparison of metabolic energy expenditure to whole-body pulmonary gas exchange measurements and previous results found with a two-dimensional approach

The thesis must contain a detailed description of all developed and used algorithms as well as a profound result evaluation and discussion. The implemented code has to be documented and provided.

Advisors: Prof. Dr. Anne Koelewijn

Student:

Start – End:

References

- [1] Zarrugh, Mohamed et al.: *Optimization of energy expenditure during level walking*. European journal of applied physiology and occupational physiology, 1974.
- [2] Koelewijn, Anne et al.: *Metabolic cost calculations of gait using musculoskeletal energy models, a comparison study*. PLOS ONE, 2019.