Biomechanical model for gait analysis in a sagittal plane

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1. Introduction

The aim of this study is to create a biomechanical model for the human gait analysis in a sagittal plane. Applying Newton-Euler formulation and Zero-Moment approach [1, 2], the numerical model for kinematic analysis and dynamical analysis was created by using own software and MATLAB programme. The scope of the study refers to compare own results with results described in literature. Proposed numerical model will be used to design a prototype of exoskeleton for rehabilitation of impaired lower limb.

2. Biomechanical model

On the base of the structural model of the human body, the biomechanical model for gait analysis was assumed as a six degrees-of-freedom structure (Fig. 1, Fig. 2). This model is composed of two legs and each leg is treated as a structure of three segments (thigh, shank and foot) connected by hinge joints.

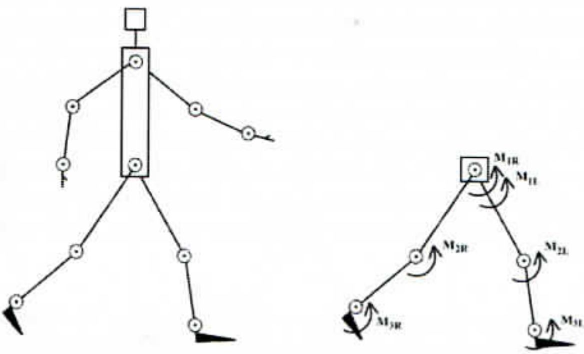

Fig. 1. Structural model of the human body (left) and biomechanical model for gait analysis (right) (MiR – the moment of the i-th actuator of the right leg, MiL – the moment of the i-th actuator of the left leg).

The influence of the upper part of the body was modelled as the concentrate force *G* (it is a gravity force of upper part of the body) and the moment of this force *M*(*G*) (Fig. 2). Proposed biomechanical model can be applied to perform kinematic/dynamical analysis by taking into account the proper phase of interaction with the ground, model of interaction and stability criterion (Fig. 3).

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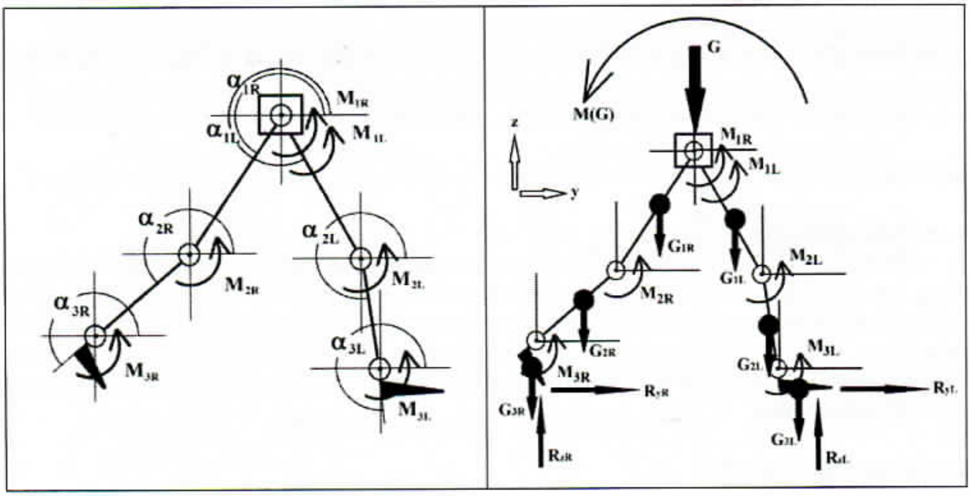

Fig. 2. Model for the kinematic analysis (left) and model for the dynamical analysis (right) (α_{iR} – the angle of the i-th segment of the right leg, α_{iL} – the angle of the i-th segment of the left leg; G_{iR} – the gravity force of the i-th segment of the right leg, G_{iL} – the gravity force of the i-th segment of the left leg; R_{yR} – the y-th component of the right leg reaction force; R_{zR} – the z-th component of the right leg reaction force; R_{yL} – the y-th component of the left leg reaction force; R_{zL} – the z-th component of the left leg reaction force; y – sagittal axis; z – vertical axis).

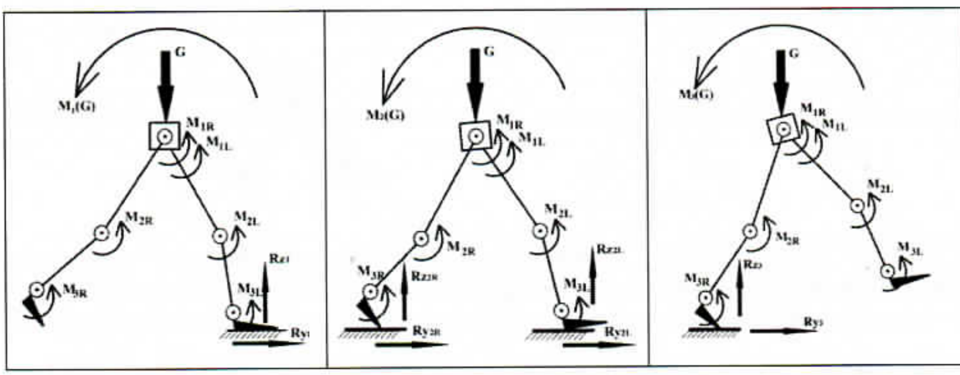

Fig. 3. Models for kinematic/dynamical analysis in the phase of: 1) single support of the left leg (left); 2) double support (middle); 3) single support of the right leg (right) ($Mj(G)$ – the moment of the gravity force of the body upper part during the j-th phase; R_{yj} – the y-th component of the leg reaction force during the j-th phase; R_{zj} – the z-th component of the leg reaction force during the j-th phase).

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