

"Model-based approaches in biomechanical movements: From the assessment to the interpretation in clinical use."

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ABSTRACT

1. Introduction

Biomechanical models are mainly used to analyse and interpret human movements. Physiological gait can be considered as a 2D movement which is cyclic and highly reproducible. The kinematics can be measured and correlated to the bone-joint and neuromuscular functions. When measuring external forces, the kinetics of the movements can be calculated on the basis of models and visualized [1].

In contrast, upper extremity movements are 3D and completely different from being restricted, repeatable or cyclic as compared to gait, and they are more complex since the joints and the multitude of muscles imply a high number of degrees of freedom. Pathological changes induce additional complications in both, gait and upper extremity movements, regarding measurement and interpretation. A proposal for how to proceed in measurements, e. g. where to place the markers and how to calculate joint angles, will be discussed which results in the description of the joint movements of wrist, elbow, shoulder and sterno-clavicular joint [2].

Biomechanical analyses in clinical daily routine are subjected to the extreme pressure of time during diagnosis and control of therapeutic progress. The decisions on the degree of pathology and restoration towards physiological ranges are essential but frequently may be based on a restricted accuracy of the analysis.

2. Methods: Upper extremity analysis

The analysis of the upper extremities starts on a common methodological platform with gait analysis. A proposal of a marker-based measurement procedure for upper-extremity motions is reported [2,3]. The kinematic model describes what is to be measured for the upper extremities based on the rigid segment approach in which each segment is assigned to one bone. By means of rigidly interconnected marker triplets the motions of each segment in all 6 degrees of freedom are assessed based on a 6-camera system. The model is made up of nine segments: the hands, the forearms, the upper-arms, the collarbones and the thorax. The joints in the model (wrist, elbow, shoulder and sterno-clavicular joint) are assumed to be ideal ball-and-socket joints. Additional markers are used to define joint co-ordinate systems which are aligned to the anatomical axes of each joint. These additional markers only used during an extra static trial, because skin

movement is largest at the joints. After having defined the joint co-ordinate systems, the joint motions can be described as relative rotations between these co-ordinate systems [3]. If the information about the kinematics of the movement is combined with the information about the underlying muscular co-ordination pattern detected by surface-electromyography [5,6], information about the individual capacity in movement performance of upper extremities is available.

3. Results

A kinematic model of the upper extremities has been evaluated in patients suffering from different movement disorders when performing movements typical for everyday life [4]. The results are presented in terms of joint angle progression for all axes of wrist, elbow, shoulder and sterno-clavicular joint. The results show that individual deficits in movement performance can be quantified and evasive movements can be identified. Additionally, a follow-up of the patients becomes possible, what opens the possibility of a more individualised therapy. In children with obstetric plexus lesion it has been shown that a combination of movement analysis and surface-electromyography contributes to a more precise diagnosis with impact on the resulting therapy.

4. Discussion

From gait analysis it is known that movement analysis in combination with surface-electromyography provides information which contributes to a more individualised therapy of patients. The introduced kinematic model allows a quantitative analysis of unconstrained upper extremity movements which may be supplemented by use of surface EMG. In this way, the benefits of movement analysis known from gait can be also applied to upper-extremity movements. Each clinical question can result in different requirements regarding precision of measurement as well as the model structure and function which, in turn, are to be adapted to the application. Sometimes, a precision lower as suspected is already sufficient for the clinical use: a model is essential but its properties also can be adapted and sometimes simplified.

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