Upper Limbs Movement Analysis for Impairment Evaluation: A Standardization Proposal

F. Sibella*, M. Galli*, F. Motta°, M. Crivellini*
* Bioengineering Dept., Politecnico di Milano, Milano, Italy
° "V. Buzzi" Children Hospital, Milano, Italy

Introduction
Interest is growing in upper limbs movement analysis in the last years, but there is no agreement yet for a unique technique or analytic method to be used in a clinical environment. The basic idea of the biomechanical model that we are describing comes from the clinical need to have a practical tool for quantitative evaluation of upper limbs impairments, particularly for non – walking patients. We are suggesting a biomechanical model that could be used in a three – dimensional setting without any constraint. It is easy to use and to explain to non – mathematically trained clinicians and could be applied also as integration to well known Gait Analysis protocols. We are also suggesting three simple clinical oriented movements as standard movements for upper limbs impairment evaluation. Normality bands have been built for each movement and pathological data can be analysed in comparison to these normal database.

Statement of Clinical Significance
Kinematic and kinetic evaluation of upper limbs movements could be relevant in the evaluation of treatment outcomes in non-walking patients; moreover, the proposed protocol could be used as an extension of the already assessed gait analysis protocols.

Methodology
25 normal subjects (age 25 ± 3 years, no musculoskeletal problems referred) and 15 children affected by Cerebral Palsy (age 15 ± 2) performed upper limbs movement analysis following the experimental protocol described by Sibella et al [1]. The three selected movements were: maximum lateral extension and back, maximum forward extension and back and taking the object to the mouth and back. Each subject performed the three requested movements twice for each limb, sitting on a chair as comfortable as possible, moving a control object on a table adjustable in height. Acquired data were analysed using the biomechanical model proposed and validated by Sibella et al [1] and Cardan angles (flexion – extension [f/e], abduction – adduction [a/a] and internal – external rotation [i/e] angle) were calculated for each joint to describe the movement. Normal subjects' data were used to build normality bands for each movement. Pathological subjects' data were then analysed by comparison with normal data.

Results
Cardan angles of the forearm relative to the upper arm for each movement are shown. In the figures normality bands (thick black lines, average value +/- 1 SD) and 4 pathological trials of a single patient (thin black lines left limb, thin grey lines right limb) are shown: f/e angle is at the top, a/a in the middle and i/e at the bottom. The pathological subject taken as example is a 13-year-old CP child affected by right hemiplegia.

1. Maximum lateral extension and back
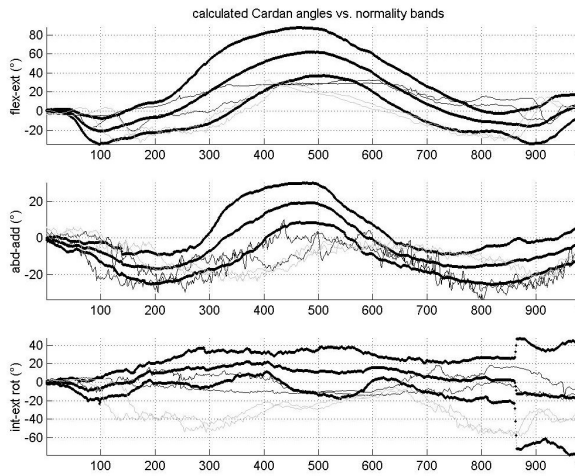
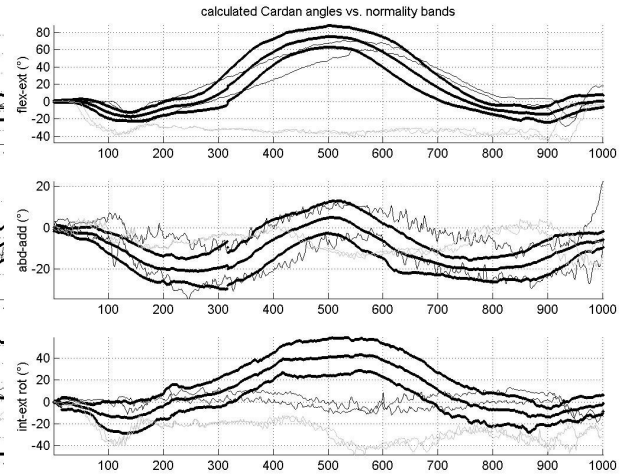## 2. Maximum forward extension and back

Fig.1: maximum lateral extension (left), maximum forward extension (right): norm bands (thick black), healthy limb (thin black), pat. limb (thin grey) of the elbow joint
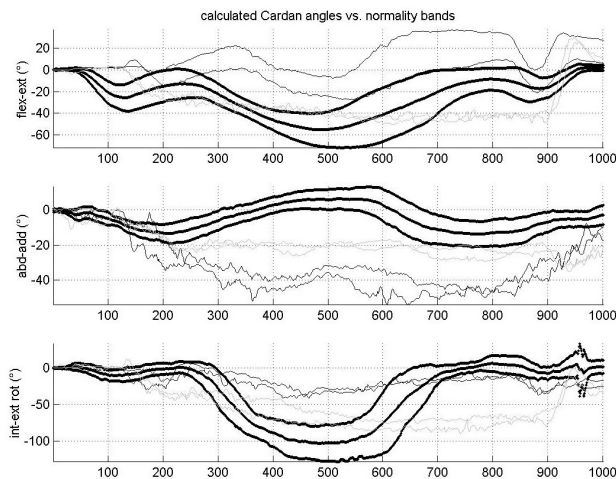
3. Object to the mouth and back

Fig.2: object to mouth: norm bands (thick black), healthy limb (thin black), pat. limb (thin grey), elbow joint

Discussion

In the figures shown above differences between normal and pathological behavior are clear to see in all three suggested movements and for all three analysed Cardan angles (f/e, a/a, i/e) in relation to the chosen joint. Differences between the movement strategies of the two limbs of the same patient can be noticed as well, a comparison between healthy and ill side is possible and could be very helpful in case of asymmetric pathologies. Many different quantitative parameters can be calculated from the proposed angular values (ROM, areas, maxima, minima, morphologic analysis…) to evaluate both pathology assessment and treatment outputs. Other significative movements can be evaluated as well and all three upper limbs joints can be analysed using the proposed model. This will be the next challenge after the approval of a standardized upper limbs motion analysis protocol and biomechanical model.

References

1. Sibella F. et al. "A new biomechanical model and experimental protocol for upper limbs movement analysis: validation…", Abstract from 7th Int. Symposium on 3D Analysis of Human Movement, Newcastle upon Tyne, England, July 10-12, 2002, pp. 48-51