THE STABILITY OF THE UPPER LIMB IN DIFFERENT SPORT EVENTS

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INTRODUCTION

The study of a biomechanic system will imply the use of many simplification hypothesis, approximation methods and optimisation techniques.The study of such a system is extremely important due to the fact that many times our body is confronted with abnormal solicitations.The stability of the shoulder girdle represents a wide direction for researchers, both from medical or (bio)mechanical point of view. In some sports events (gymnastics, javelin throwing etc.) knowing the behaviour of the shoulder system is a very useful tool for sportive, trainer and the sportive medical doctor. The analysis of the shoulder girdle system is a difficult task, both from experimental or theoretical perspective. The main advantage of using experimental techniques reside, in principal, in obtaining high degree of confidence results. But, in the same time, the difficulties of such experimental studies are high enough. On one hand, the experimental procedures imply the use of high costs apparatus and on the other the subject can not always perform at his maximum capabilities due to the presence of markers, wires etc. The use of theoretical models has to prove their validity reducing the costs of the research. In this paper we will try to develop an improved analytic model that could be used for analysing the behaviour of the shoulder girdle mechanism.

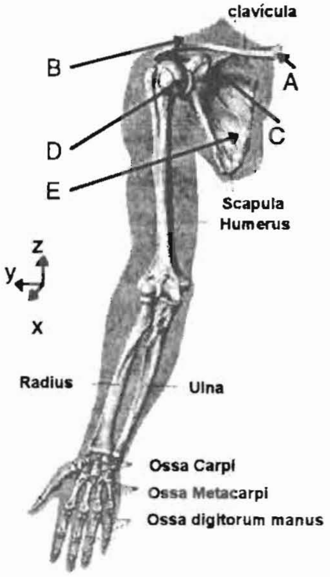

Fig. 1 A - sternoclavicular joint; B - acromioclavicular joint; C - scapular ramification point; D - glenohumeral joint; E - scapulothoracic gliding plane (modified from Gray, 1986)

METHODS

The shoulder girdle, according to anatomic description, presents four elements: thorax, clavicle, scapula and humerus and next joints: sternoclavicular (A), acromioclavicular (B), glenohumeral (D) and the scapulothoracic gliding plane (E), as shown in fig. 1. The dimensions of these were taken from classic antropometric studies (Bart, 1957). To model the kinematic chain the specified joints were modelled as follows: the A, B and D joints as spherical joints (each of these possessing three degrees of freedom- dofs) and the E joint as presenting 4 dofs. We would like to underline the fact that the definition for the number of dofs that characterise A and B joints reflects last hour experiments (Pronk, 1991; van der Helm, 1992, 1994; Veeger, 1992) and contradicts previous limited definitions for these joints mobilities.The above mentioned mobilities characterise a general movement of the upper limb.The Denavit-Hartenberg matrix formalism allows to obtain the kinematic model.

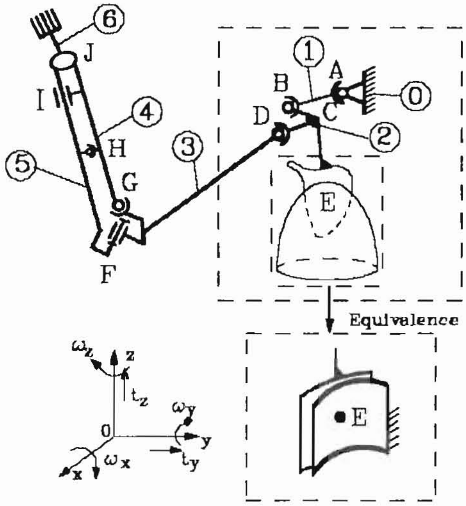

Fig. 2 The shoulder girdle mechanical model

RESULTS

The obtained results are touching kinematic and dynamic aspects. From kinematic point of view these results respect the natural behaviour of the shoulder girdle. From dynamic point of view the results are more interpretable and are pointing outside the frame of the present paper For peculiar movements (flexion-extension or abduction-adduction) these mobilities are reduced (Pronk, 1991; Rinderu, 1995). In fig. 2 is presented the considered model for applying characteristic analysing techniques of the theory of mechanisms. In this way was possible to derive the kinematic behaviour of the considered kinematic chain. Knowing the kinematics of the mechanism, the evolution in phases plane (that permits to find information about the stability of the system) is easily obtained. Interesting conclusions were found, identifying (for different movement cycles) the points were the systems is stable, at limit stable or unstable. Fig.3-6 present some of the kinematic results concerning one of the most sensitive and solicited joints of the shoulder system, the glenohumeral joint. Fig. 7-10 show the evolution of the system in the phases plane for some points of the kinematic chain.

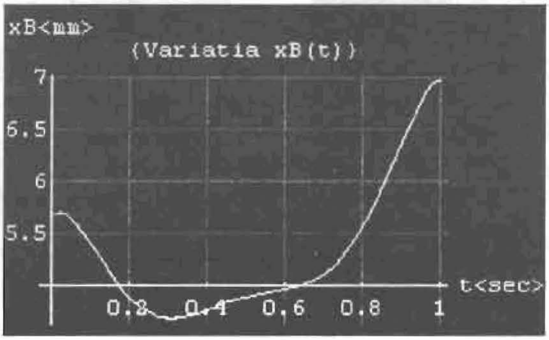

Fig. 3 x(t) plot for the centre of B joint

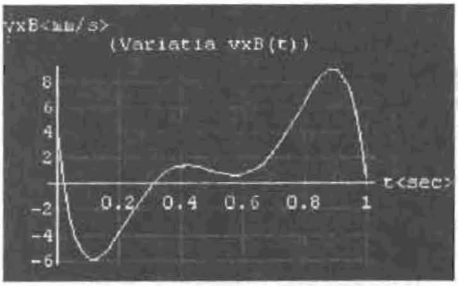

Fig.4 The velocity of the B joint centre in projection on Ox axe

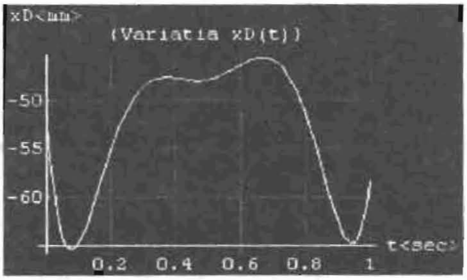

Fig. 5 x(t) plot for the centre of D joint

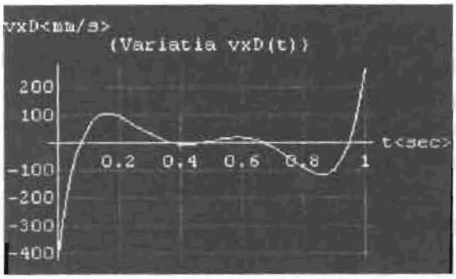

Fig.6 The velocity of the D joint centre in projection on Ox axe

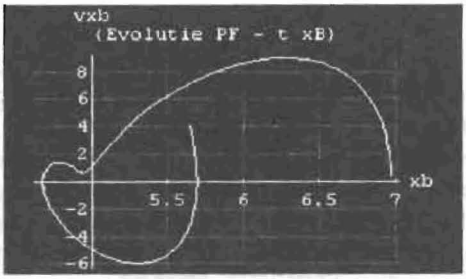

Fig. 7 Phases plane evolution for B joint centre in projection on Ox axe

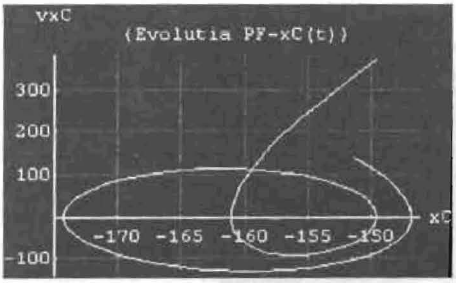

Fig. 8 Phases plane evolution for C point in projection on Ox axe

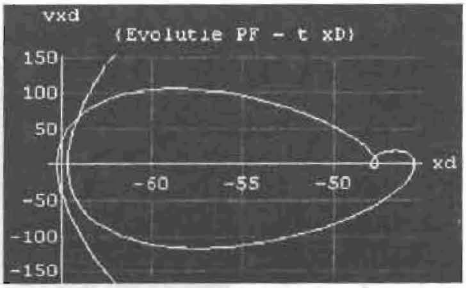

Fig. 9 Phases plane evolution for D joint centre in projection on Ox axe

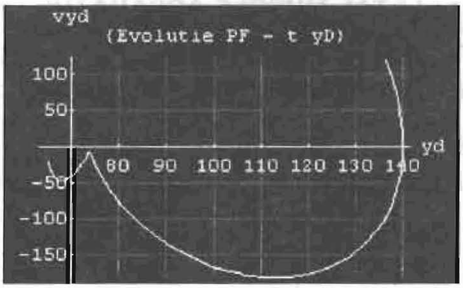

Fig. 10 Phases plane evolution for D joint centre in projection on Oy axe

CONCLUSION

Analysing fig.7-10 is possible to identify the fact that, for example, in the javelin throwing event (approximately a flexion-extension movement of the upper limb), in the range of 80°-100° the system presents changes in the stability definition.Taking into consideration discussions with sportives, trainers and sportive medical doctors, this range of values coincides with the most soliciting situation during this event.The result, as presented in high confidence studies (van der Helm, 1991, 1994), coincides also with the situation of maximum force in the glenohumeral joint.The presented model can be used for analysing the behaviour of this biomechanism and for predicting its comportment in the case of different sports events, especially from stability point of view.

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