INTRODUCTION

In the last decades several research projects have focussed on the biomechanical evaluation of lumbar spine instability by using either imaging techniques and isokinetik tests, the latter being now currently used for clinical assessment. To our knowledge a similar approach is still not available for the cervical spine at least as a routinely adopted practice, also because of the risk related to restrained motions of the head, mainly in the case of injured subjects. The aim of the present study was therefore to provide a new protocol for cervical spine clinical and biomechanical evaluation during unconstrained paced head rotations as an integrated tool in diagnostic procedures.

METHODS

A group of ten healthy volunteers ranging from 25 to 36 years old were examined. None suffered from cervical pain or other related symptoms. A set of 21 spherical reflective markers were placed directly on the skin of each subject with the aid of adhesive dot. Facial glabella, temporum mandibular joints, acromions, shoulder blade posterior spines, C7, T3, T6, T9, T12, L1, L3 and L5 spinal processes, sacrum and PSIS were selected as anatomical marker sites (see Figure 1a). An adjustable helmet carrying three additional markers was used to investigate the physiological motion-match with respect to head rigid-body-like movement.

![Figure 1](image_url)

Figure 1: (a) Positioning of markers in accordance with the proposed protocol for motion capture–based analysis of cervical spine disorders. (b) Right/left paced unconstrained head rotation in seated position.

A motion capture system (Smart - eMotion s.r.l., Padova, Italy) supplied with six infrared cameras allowed the monitoring and software storage of each marker position in a virtual anatomically-oriented coordinates system. The subjects were instructed to perform five unconstrained paced head rotation in seated position (see Figure 1b) at medium and fast motion rate – 20 and 45 cycles/min respectively – trying to span the whole ROM in both right and left side. Besides the head, two other groups of markers were separately identifiable: the low back cluster and the markers located in the shoulder upper district. In such a way it was possible to refer the head position alternatively to the shoulder or to the pelvis, obtaining a deeper insight into the contribution of each motion unit. Data processing was performed by using in house automatic routines implemented in Matlab. The analysis was aimed to determine (1) range of motion, (2) left/right side ROM asymmetry, (3) head instantaneous rotational axis trajectory, (4) head motion control capabilities at different motion rates.

RESULTS AND DISCUSSION

The protocol allows the determination of full head movements in absolute or relative coordinates; in particular the relative rotation between head and shoulder (θ_{HS}) and shoulder and pelvis (θ_{SP}) can be evaluated and plotted with informations about their timing sequence. Furthermore, the head angular velocity (ω_{HS}) can be plotted in polar coordinates as function of the head-shoulder relative angle (θ_{HS}) as shown in Figure 2. When comparing right side and left side, θ_{HS} may result asymmetric. Moreover, as the head approaches the range motion limits, ω_{HS} shows clear oscillations due to the muscle activation and the increasing of anatomical restraints. In the graph reported below, there are no pronounced peaks of ω_{HS}. This finding is fairly predictable since the volunteers examined so far do not suffer from any functional deficiency affecting the head motion at least in unconstrained rotations.

Further investigations are being carried out to allow for comparison with subjects with known pathologies or traumas such as whiplash injuries.

![Figure 2](image_url)

Figure 2: Angular velocity ω_{HS} (red line) versus angular position θ_{HS} (blue line) during paced unconstrained head rotation (at 20 cycles/min).

SUMMARY

Aim of this study was to provide a reliable method for cervical spine biomechanical evaluation by using motion capture system. A new protocol for clinical assessment and reporting was formulated in terms of markers placement, test procedures and data processing. Head rotational axis path, speed and ROM features might be related to injury background or to pathological disorders.

REFERENCES