INTRODUCTION

Functional assessment of the human cervical spine often involves the measurement of overall cervical spine motions while a test subject or patient performs active range-of-motion (AROM) maneuvers in flexion/extension, axial rotation, and lateral bending. Poor or arbitrary control of voluntary movements by the subject or patient being examined can unduly influence the measured motions—thereby decreasing the reliability of the kinematic data. The objective of the present study was to test the efficacy of a recently developed magnetic tracking/virtual reality (VR) based system for aiding in the control of voluntary cervical spine movements during active functional assessments. We hypothesized that VR-assisted visual feedback of overall cervical spine rotations would enable subjects to reduce the magnitude of secondary rotations during the performance of AROM maneuvers.

MATERIALS AND METHODS

The magnetic tracking/VR-based system consists of a magnetic tracking system (Flock of BirdsTM, Ascension Technologies, Inc., Burlington, VT), head mounted display (Virtual i-O™ Personal Viewing Glasses, Virtual i-O, Seattle, WA), and programmable visual interface, operating under the control of a personal computer. Ten healthy male volunteers (ranging in age from 19 to 38 years, free of neck pain and with no history of spinal problems) participated in this study. The subjects performed maximal cervical spine AROM maneuvers in flexion/extension, left/right axial rotation, and left/right lateral bending—first without and then with VR-assisted visual feedback of their overall rotations. Verbal instructions were given to encourage maximal overall cervical spine movement in the primary rotational degree-of-freedom and minimal movements in the secondary rotational degrees-of-freedom. For AROM maneuvers with VR feedback, computer-generated visual feedback of overall cervical spine rotations was provided to the subjects as an aid to control of their movements.

The mean primary and secondary rotations at the extremes of primary movement for each of the six AROM maneuvers—without and without VR feedback—were computed for each subject (based on the means of three trials per maneuver) and for the group. Absolute values of the secondary rotations, representing the magnitude (without regard to the sign/direction) of the difference between the actual and targeted (0°) secondary rotations, were also computed. Data with and without VR feedback were compared using paired t-tests (significance was set at p<0.01 to account for multiple comparisons).

RESULTS

Figure 1 shows raw data plots of overall primary and secondary cervical spine rotations vs. time for selected lateral bending AROM trials performed by one subject, first without and then with VR feedback. Without VR feedback (Fig. 1A), primary lateral bending was accompanied by large secondary rotations in flexion/extension and axial rotation—despite the subject having been verbally instructed prior to the effort to minimize these secondary rotations. With VR feedback (Fig. 1B), the subject was able to reduce both of these secondary rotations to nearly 0° at the extremes of primary movement—without reducing peak primary (lateral bending) rotation.

The mean primary and secondary cervical spine rotations vs. time for lateral bending AROM maneuvers with VR feedback (Fig. 1B) are compared to those without VR feedback (Fig. 1A) in Table 1. The mean primary and secondary cervical spine rotations without VR feedback (data not shown). No statistically significant differences were detected between corresponding mean primary rotations achieved with and without VR feedback (data not shown).

DISCUSSION

Virtual reality (VR) assisted visual feedback of kinematics has been found in the present study to aid in the control of voluntary cervical spine movements during active functional assessments. The results support our hypothesis that VR feedback would enable subjects to reduce the magnitude of secondary rotations during the performance of AROM maneuvers. Moreover, voluntary reduction of secondary rotations did not compromise primary rotations—suggesting that the secondary rotations produced during AROM maneuvers without VR feedback originated mainly from poor/arbitrary control of movements (rather than from mechanical coupling within the osteoligamentous cervical spine).

Judicious administration of VR feedback during active functional assessments of the cervical spine may therefore be helpful in reducing that part of the variability of the kinematic data that is due to poor/arbitrary control—thereby improving the specificity of active assessments for detecting true differences in function due to aging, degeneration, injury, surgery, rehabilitation, and other agents.

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