MAXIMUM ARM ELEVATION INVOLVES DIFFERENT SPINOPELVIC MOBILISATION MECHANISMS IN THE ASYMPTOMATIC POPULATION

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Introduction

The physiological range of motion of the shoulder complex is limited to 150° [1,2]. Therefore, the possibility to elevate the arms over 150° involves the participation of other joints. Previous studies showed that arm elevation was associated with 3-D rotations of the thoraco-lumbar and cervical spine [1-4]. The kinematics patterns suggest compensation mechanisms between different sections of the spine. To date no studies assessed the spine analytically (vertebra by vertebra). A better knowledge of the 3-D kinematics of the spine during arm elevation should help to understand the biomechanics of arm elevation and better consider the stress on anatomical structures.

Material and methods

Nine right-handed asymptomatic volunteers were included (5 women, 4 men; mean [SD] age 24.9 [3.0] years; mean height 170 [11] cm; mean body mass index 23.5 [2.6] kg/m2). The study protocol was approved by a local institutional review board (CPP-IDFIII, no. 2013-A00660-45). Biplanar X-rays (sagittal and coronal) were acquired in 4 levels of humero-thoracic elevation: bilateral flexion 30° (E30), left arm flexion 140° (E140) and 180° (E180) and 180° elevation in the scapular plane (S180). Pelvis and spine were digitalized, with a template and a detailed 3D reconstruction respectively [3] enabling to compute postural parameters. Friedman's ANOVA was performed followed by two-by-two Wilcoxon Signed-Rank tests when needed for comparing the mean parameters values in different positions. Variations in the position of the head, pelvis, and vertebrae (C3 to L5) were visualized using simplified geometric models.

Results

Mean sagittal curvatures T1T6 and L1S1 and frontal curvatures T7T12 and L1L5 were not significantly different between the four positions. Significant decrease in mean sagittal curvature C3C7 and T7T12 was observed between E30/E140 and maximal elevation positions E180/S180. All sagittal curvature parameters, regardless of position, had a standard deviation greater than 6° (max. 13°). The frontal curvatures and axial rotations did not exceed 10° in absolute value in 89% and 98% of the cases respectively.

Figure 1 illustrates two distinct examples of pelvis and spine kinematics The pelvis hardly moves for subject 1 while subject 2 leans forward. Subject 1 makes a left lateral bending at E140 and remains upright in the other positions while Subject 2 makes a progressive right lateral bending as the level of arm elevation increases.

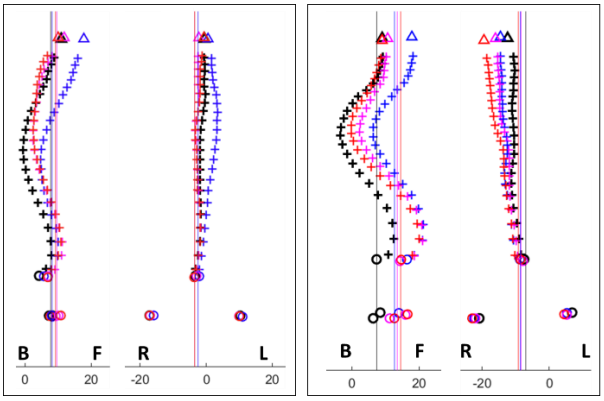

Figure 1 Simplified model visualisation for two subjects (1: left, 2: right). ⊙ pelvis points; + vertebral body centres; △: odontoid tip. The vertical lines run through the middle of the acetabula. Black: E30; Blue: E140; Magenta: E180; Red: S180.

Discussion and Conclusion

In this study, asymptomatic subjects were asked to adopt simple, standardized, position of arm elevation. Although a mean pattern of reduction in cervical lordosis and T7T12 sagittal curvature was identified at maximal arm elevation levels, a large variability in strategies was observed. 6/9 subjects move substantially their pelvis, on average forward (2cm from E30 to S180) and without axial rotation. The head was also mobilized but generally within a 5cm displacement limit in the transverse plane. However, 3/9 subjects adopted an unbalanced strategy by not keeping their head above the pelvis (distance between the centre of the acetabula and the odontoid in the transverse plane greater than 5cm).

This study shows different pelvis and spine strategies to achieve the same arm position. Our results suggest that sophisticated personalized mechanisms are involved in such simple tasks as arm raising. Further work is needed, through investigations on a larger number of subjects, to identify the morphological, postural and biomechanical determinants of a strategy for this movement, including the upper cervical level.

References

1. D. Theodoridis, et al., Clin Biomech, 17:418–421, 2002.
2. F. Fayad et al., Brain Res, 1191:107–115, 2007.
3. K. Takahashi et al., J Orthop Sci, 20:624–632, 2015.
4. A. Roren et al., Ann Phys Rehabil Med, 63:6, 372-375, 2020
5. L. Humbert et al., Med. Eng. & Phys., 31:6, 681:687, 2009.