THE IMPACT OF USING DIFFERENT CALCULATION METHODS AND LOCAL COORDINATE SYSTEMS WHEN MEASURING 3D SCAPULAR ATTITUDES

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INTRODUCTION

The normal range of scapular rotations during arm elevation of healthy subjects significantly varies from one study to another. Some factors suggested to explain this variation include differences between studies in the kinematic definition of scapular movements. For example, Karduna et al. have shown that, when calculating motion of the scapula, altering the sequence of rotations has a major impact on the magnitude of the estimated scapular motion in each plane [1].

The International Shoulder Group (ISG) has proposed standard definitions of the joint coordinate system for the reporting of shoulder motion to allow a better comparison of results between studies [2]. However, the impact of using different local coordinate reference systems and different methods of calculation when characterising scapular movements remains to be investigated. The objective of this study is to compare the 3D scapular attitudes (3DSA) obtained when using two different local coordinate systems and two different methods of calculation of relative movement.

METHODS

In a seated position, the 3DSA of both shoulders of 15 healthy subjects (mean age 37.8 ± 13.2 years) were measured in two shoulder positions: 70° of flexion and 90° of abduction. The 3DSA was calculated using the Optotrak Probing System (Northern Digital Inc., Waterloo, Ontario, Canada). For each trial, three non-collinear bony landmarks on the scapula (trigonum spinea, angulus inferior and angulus acromialis) and on the trunk (C7 spinous process and the right and left postero-superior iliac spines) were digitized.

Two methods of calculation of relative movement were used to determine the 3DSA. First, the 3DSA with the arm in elevation was calculated with respect to the position of the scapula with the arm at rest; and secondly, the 3DSA was calculated with respect to the trunk. 3DSA were also calculated using the local coordinate reference system proposed by the ISG [2] and by Hébert et al. [3] (Figure 1). The mean of the 3DSA of the 30 shoulders was used to compare the methods of calculation and reference systems. A *t-test* was performed to evaluate the differences.

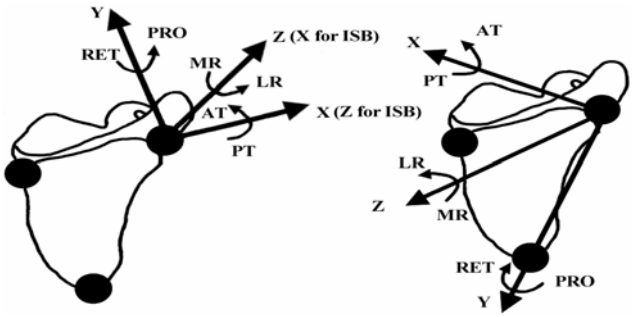

Figure 1: Local coordinate reference system proposed by ISG (left) and Hébert et al. (right)

RESULTS AND DISCUSSION

Altering the method of calculation has the most significant impact on the magnitude of the scapular rotations calculated (Table 1A). This finding is not surprising since the two methods are so different. One method calculates the displacement of the scapula from its position at rest, while the other calculates the changes in the orientation of the scapula with respect to the trunk. When interpreting findings from different studies in which different methods of calculation were used, one must be careful to make comparisons.

Using different local reference systems has less impact on the 3DSA, except in medial-lateral rotation for the method with respect to the trunk (more than 45°) (Table 1B). In this latter plane of movement, the differences in the orientation of the y-axis seem to have brought important changes of attitudes.

These results support the ISG recommendations to adopt standards for joint coordinate systems and method of calculation to allow a better comparison and benchmarking between studies. However, as there is so much variability between methods and systems, the choice of standard parameters must be based on their capacity to best characterise normal and abnormal patterns of movement.

REFERENCES

1. Karduna AR, et al. *J Biomech* **33**, 1063-1068, 2004.
2. van der Helm FCT, et al. (in press) *J Biomech*
3. Hébert LJ, et al. *Clin Biomech* **15**, 1-8, 2000.

Table 1: Differences of 3DSA between **A.** methods of calculation of relative movement and **B.** local coordinate reference systems

		A. Methods of calculation: Scapula at rest vs. Trunk				**B. Local reference system: Hébert et al. vs. ISG**			
		LCRS of Hébert et al.		LCRS of ISG		MC w.r.t. Scapula at rest		MC w.r.t. Trunk	
		Difference (°)	p	Difference (°)	p	Difference (°)	p	Difference (°)	p
Flexion 70°	A-PT	15.0	<.0001	12.7	<.0001	1.2	0.004	1.1	0.0004
	L-MR	41.8	<.0001	5.6	<.0001	1.6	0.01	45.8	<.0001
	Pro-Ret	27.5	<.0001	31.0	<.0001	0.0	0.59	3.5	0.0001
Abd 90°	A-PT	23.0	<.0001	22.6	<.0001	0.4	0.44	0.0	0.84
	L-MR	38.8	<.0001	9.2	<.0001	0.5	0.54	47.5	<.0001
	Pro-Ret	34.1	<.0001	35.3	<.0001	0.0	0.71	1.2	0.15

Abbreviations: A-PT, anterior-posterior tilting; L-MR, lateral-medial rotation; Pro-Ret, protraction-retraction; w.r.t., with respect to; LCRS, local coordinate reference systems; MC, method of calculation of relative movement; Abd, abduction.