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Technical note

Shoulder motion description: The ISB and Globe methods are identical

George T. Rab [a,b,*]

[a] Department of Orthopedic Surgery, University of California Davis, Sacramento, CA, USA

[b] Shriners Hospitals Northern California, Sacramento, CA, USA

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Abstract

Background: Three-dimensional shoulder position may be described by rotation sequences such as the proposed ISB standard. Alternative techniques to describe position (the Globe method) seek to simplify this description by eliminating rotation sequences and substituting unambiguous measurements.

Methods: Both methods (ISB and Globe) were applied to an analysis of shoulder positions, and an overall comparison was performed.

Findings: The ISB and Globe methods are numerically identical and interchangeable.

Interpretation: While all analytic methods are mathematically equivalent, investigators have sought simpler and more easily-applied ways of describing shoulder position that would be accurate, easily understood by clinicians, and unambiguous. This study demonstrates that the ISB rotation sequence and Globe descriptive method are numerically the same.

Keywords: Upper limb; Motion analysis; Shoulder

1. Introduction

The description of shoulder motion involves complexities that are unique to the joint. The dual nature of the anatomic structures involved in movement of the shoulder complex (scapulo-thoracic and gleno-humeral joints) has proven difficult to quantify [5], except by cumbersome methods (palpation, ultrasound, or MRI [2,4]). Even if the shoulder complex is simplified to movement of the humerus relative to the thorax, different rotation sequences and philosophies make comparison of upper extremity motion studies challenging.

The Cardanic method of three sequential angles about the individual axes of a moving Cartesian coordinate system imbedded in the distal segment has been widely used in human gait analysis, and has found application in upper extremity investigations [7]. However, difficulties applying this method in regions of 90° shoulder abduction have led to consideration of other techniques. An et al. described a sequence of three rotations that rotates the humerus to a plane of elevation, through an angle of elevation, and to a new rotational humeral position [1]. The first and third rotations are about the longitudinal axis of the humerus, and the second rotation is about the forward-directed humeral axis. This sequence was used to describe isolated humeral motion with respect to the scapula, and it is not always intuitive because the entire upper extremity must first rotate to the plane of elevation, and then must be rotated ‘‘back’’ to its final position after elevation of the humerus. Using different axis definitions, the International Society of Biomechanics (ISB) [8] proposed a similar standard for description of shoulder kinematics. The zero point of the plane of elevation is lateral (frontal plane) and the 90° plane of elevation is forward (sagittal plane); these definitions may confuse clinicians.

The ISB method is a sequence decomposition from a base starting position to the actual limb position. While engineers

* Correspondence address: Department of Orthopedic Surgery, University of California Davis, 4860 Y Street, Suite 3800, Sacramento, CA 95817, USA. Tel.: +1 916 734 5770; fax: +1 916 734 7904.

E-mail address: george.rab@ucdmc.ucdavis.edu.

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understand this, clinicians without engineering expertise may not understand why the position cannot simply be ''measured'' without the necessity of strict sequences. Pearl et al. [6] attempted to solve this problem practically by *defining* the plane of elevation (the longitude of a Globe), but not actually *rotating* the arm to this position. The angle of elevation of the humerus is measured in that plane. Finally, humeral rotation is *described* by the angle of the 90° flexed forearm with the line of latitude at the elbow. Thus, Pearl substituted a definition, measurement, and description set for a sequence of three rotations. This is an important difference from the ISB method, as it is easier for clinicians to understand, and it mimics practical measurement methods commonly employed by physicians, therapists, etc. While an ordered set of numbers is used to describe position in the Pearl method, the measurement of angles in Pearl's approach is actually sequence-independent. A similar system is described by Doorenbusch et al. [3] These methods are designated the Globe method in this paper.

Selection of a specific method for reporting results is often determined by the ease of description of motion in a specific region of interest. The Cardanic sequence is best suited to activities directly forward of or behind the shoulder, and the other methods (ISB and Globe methods) are suited to movement at the side, particularly when the arm is abducted (such as throwing). Despite similarities, the ISB

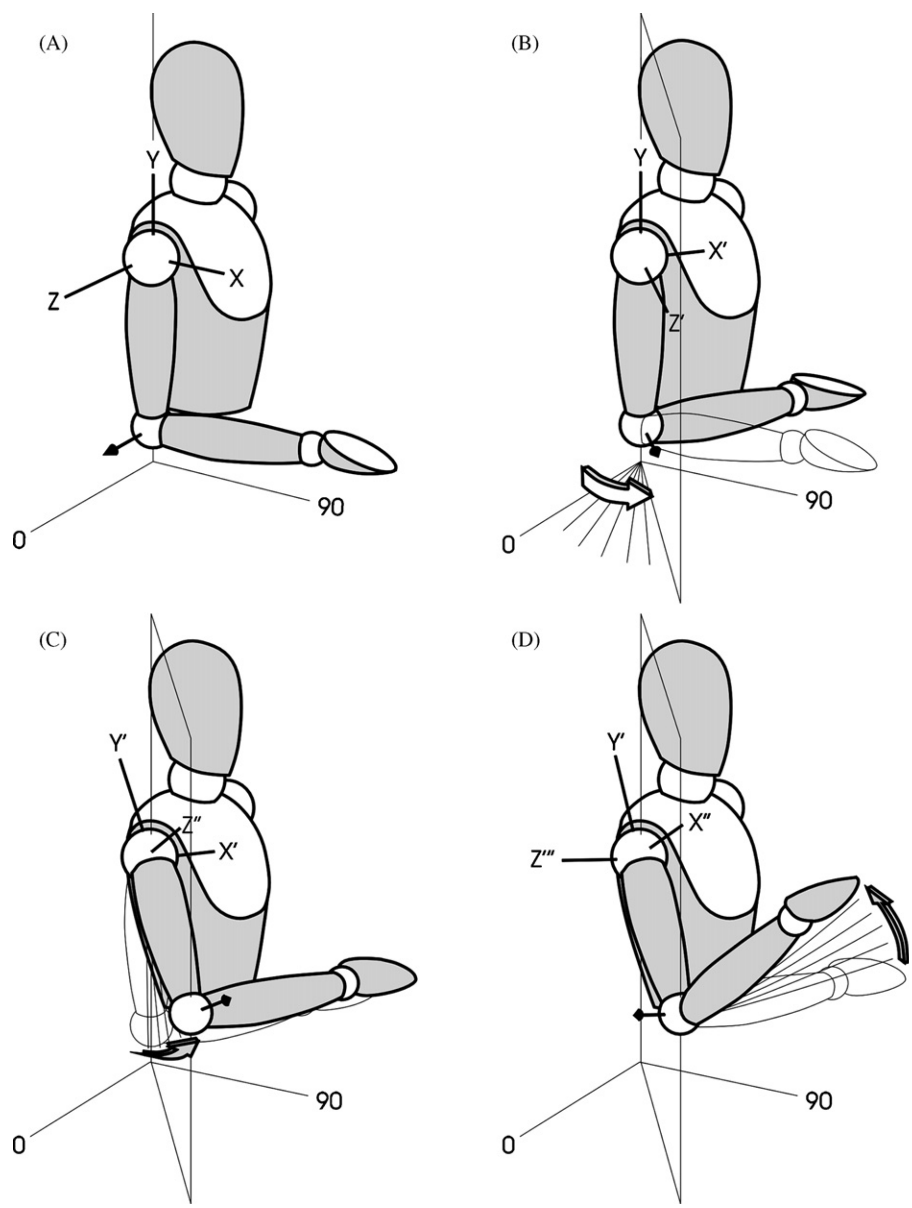

Fig. 1. ISB method applied to an articulated model position. (A) Initial position, with vector pointing laterally (humeral Z-axis) at 0° on the XZ plane. (B) The humerus is first rotated about its Y-axis until the humeral Z'-axis points to the plane of elevation. Note that the forearm (elbow 90° flexed) and X-axis are horizontal at this point. (C) The humerus is elevated about its X'-axis. Note that the forearm and X-axis remain horizontal, parallel to the XZ plane. (D) The humerus is externally rotated about its Y'-axis by to the final position. The Y'-axis is normal to the plane containing the rotating forearm.

and Globe methods have not been explicitly compared. In this paper, they are shown to be numerically identical.

The arbitrary coordinate system in the discussion below is a right-handed Cartesian system, applied to the right shoulder, with the X-axis directed anteriorly, Y-axis directed superiorly, and Z-axis directed laterally. These are the axes used in the ISB standards. Rotations about these axes are positive following the "right-hand rule." Studies of the left shoulder will need to take this into account, or utilize a left-handed system. In the anatomic (resting) position, local coordinate systems of the trunk and humerus are coincident.

Consider the application of the ISB sequence and the Globe method to an articulated model, with the elbow flexed at 90° for simplicity and for deriving the Globe humeral rotation. Both methods determine rotation from the laterally directed humeral Z-axis (cross-product of forearm and humerus), so the frontal plane is the 0° plane of elevation, and the sagittal plane is the 90° plane of elevation.

The ISB method involves a specific sequence of rotations from a base anatomic position to bring the imbedded humeral coordinate system to a desired final position (Fig. 1A). The laterally directed Z-axis of the humerus points in the direction of the plane of elevation after the first rotation (Fig. 1B). This may seem clinically counterintuitive when describing positions of pure flexion of the shoulder, since the position after the first rotation is one of 90° internal rotation. The flexed forearm and anteriorly directed X-axis are horizontal (XZ plane) at this point. After the second rotation (angle of elevation), the forearm segment is still always horizontal, since it is at right angles to the vertical plane of elevation (Fig. 1C). The third rotation (Fig. 1D) reduces to a rotation about the humeral Y-axis, away from the horizontal plane—exactly the same angle as the description of rotation used by Pearl and Doorenbusch et al. in the Globe method [3,6].

The Globe method (in practical terms) measures the detected position of the humerus relative to that of a base

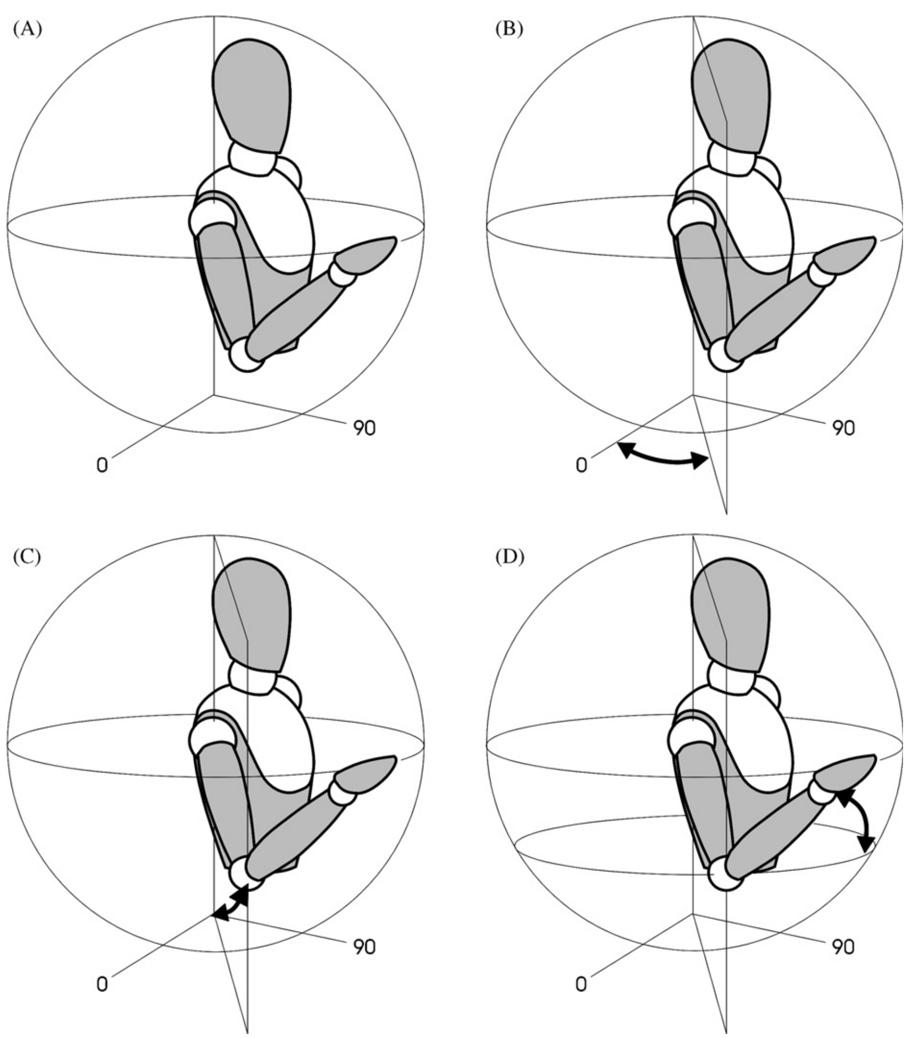

Fig. 2. Globe method applied to the model in the final position of Fig. 1D. (A) In this figure, a Globe is superimposed on the model, with center at the shoulder joint and a diameter equal to humeral length. (B) Plane of elevation is defined as the projection of the humerus onto the horizontal plane. (C) Angle of elevation of the humerus is measured. (D) The forearm rotation is measured as a deviation from the local latitude passing through the elbow joint, in a plane tangent to the sphere at that point. This plane is normal to the longitudinal humeral axis, and is therefore the same as described in Fig. 1D.

frame located in the trunk segment. Using the Globe description, a plane of elevation is derived from the projection of the humerus onto the horizontal plane (Fig. 2B), and the humeral elevation is the angle between the global (trunk) longitudinal axis and the humeral longitudinal axis (Fig. 2C). The actual rotation of the humerus along its longitudinal axis is unimportant at this point, since it is described by the third element of the Globe description—the inclination of the flexed forearm with the global latitude passing through the elbow in a plane tangent to the sphere at the point of the elbow (Fig. 2D). The set of three numbers thus generated is ordered to identify each, but note that any of the three measurements can be made independently of the other two, without regard to sequence.

2. Discussion

Despite attempts to standardize description of upper extremity motion, there remains no universally accepted method. Experts disagree about naming of axes as well as rotation sequences, and propose in their manuscripts that some methods are ''unambiguous'' or ''clear and simple.'' Behind this debate lie the facts that certain regions of movement are poorly described by specific methods, and methods may vary for different clinical or research objectives. The most commonly used rotation sequences (Cardanic, ISB) are well-described and validated. Other descriptions, such as the Globe methods, are intended to make interpretation easier, or more practically linked with observational clinical analysis of motion. In fact, they do. Clinicians may appreciate the similarity with standard physical examination techniques that seems to be afforded by the Globe method, although mathematically inclined investigators may initially have concern that it is descriptive rather than rigorous. The ISB method requires a strict sequence of rotations, whereas the Globe method measurements may be made in any order.

In this paper, it is demonstrated that the ISB standard and the Globe methods described here are identical, and that the set of numbers may be rigorously interpreted as a sequence of rotations, or as a more loosely applied set of measurements, all with equal mathematical validity.

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Conflict of interest

The author has no personal or financial relationships with persons or organizations that could influence this work.

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