Spartacus: an open dataset of normal shoulder girdle kinematics

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Summary

Quantifying 3D shoulder girdle kinematic deviations in various fields requires reference values. Existing datasets collected using gold-standard measurements often suffer from inconsistencies limiting their utility. The present study aggregates 20 datasets within Spartacus, an open dataset aligned with the International Society of Biomechanics (ISB) recommendations. Spartacus includes data from 245 shoulders and applies corrections to address six deviations in local coordinate system (LCS) definitions and joint kinematics computation. Openly available, Spartacus enables exploration of shoulder girdle kinematics, promotes standardisation, and provides a robust dataset to further question the shoulder kinematics.

Introduction

The shoulder girdle has the greatest range of motion in the human body. Its 3D kinematic analysis is essential across numerous disciplines: in medicine for diagnosing joint disorders, guiding treatments, and evaluating outcomes; in sports for enhancing performance and preventing injuries; and in computational biomechanics to guide upper-limb modelling choices. Having reference 3D kinematics of asymptomatic shoulders is key to these applications. Gold-standard methods employing intracortical bone pins and medical imaging means face ethical and experimental limitations, leading to sparse datasets. Additionally, these studies often lack consistency in LCS definitions and joint kinematics computation, limiting their utility.

The present study addresses these gaps by creating Spartacus, an open dataset of aggregated shoulder kinematics. Using the ISB recommendations [1], it unifies datasets, identifies deviations, and applies corrections or compensations.

Methods

We identified original sources from the literature (up to December 2023) through extensive database searches. Inclusion criteria required reporting at least one rotational or translational degree-of-freedom obtained *in vivo* or *ex vivo* from asymptomatic populations during uniplanar arm motions, expressed as continuous series based on one thoracohumeral angle. Data unavailable directly from authors were digitised, grouped into datasets, and standardised.

Using the ISB recommendations as a reference, six deviations were identified in LCS definitions and computation of joint kinematics. These deviations were summarised, scored, and addressed through correction methods when possible. Compliance scores expressed as percentages revealed trends in adherence to the ISB recommendations. Spartacus unifies these datasets into an open source data repository [2].

Results and Discussion

We identified 20 datasets from 30 sources. Raw data were obtained from 10 out of 20 authors, and the aggregated datasets, with 76 features, are available in the Spartacus repository [2]. These datasets vary in experimental conditions, measurement methods, and motion types, covering various uniplanar arm motions.

A significant variability was observed across datasets in LCS definitions and joint kinematics computations. Deviations were most prevalent at the segment level, with full ISB compliance achieved in only 22–42% of cases. At the joint level, full compliance was observed in only 0–33% of cases. Deviations were corrected when possible, resulting in 39 adjustments. The corrected data are available for interactive exploration through Spartacus.

Conclusions

Spartacus represents a milestone in advancing our understanding of normal shoulder girdle kinematics. We meticulously compiled original articles that employed gold-standard measurement techniques. Spartacus offers a significant update and expansion of the field's knowledge base. It is also proposed as a foundational tool for future studies, enabling comparisons of new and existing data while serving as a continually evolving open-source resource. The authors assert that Spartacus will play a key role in enhancing the quality and consistency of future research in shoulder girdle kinematics.

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References

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