Repeatability of Shoulder Elevation in the Scapular Plane Using Different Assistance Methods

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Introduction and Aim

Shoulder elevation in the scapular plane, also called scaption, involves raising the arm in the plane of the scapula, which is 30° to 40° anterior to the frontal plane. Combining flexion and abduction, scaption is relevant in rehabilitation, especially after labral repairs or reverse shoulder arthroplasty, as it reduces tension on repaired structures [1]. Three different guidance methods for performing scaption were compared, with the aim of investigating the repeatability of the elevation plane joint angle among a sample of subjects.

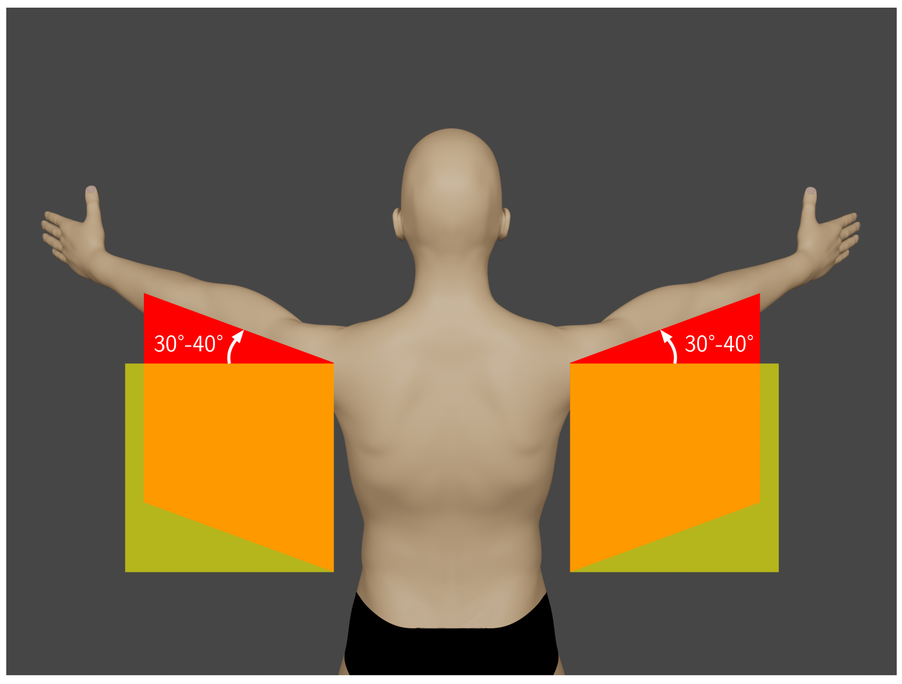

Figure 1: Shoulder elevation in the scapular plane (red). The frontal plane is highlighted in yellow.

Methods

Seven volunteers (M/F: 5/2, right/left-handed: 6/1, mean age: 27 years, no shoulder pathologies) participated in the study. After palpation, markers were placed on the thorax landmarks (IJ, PX, C7, T8), scapula (AA, AI, TS, PC, AC), and humerus epicondyles (ME, LE) of the dominant limb. Clusters were positioned on the acromion (AMC, Figure 2a), upper arm, and thorax [2]. The bone-embedded frames were defined as recommended by the ISB and tracked with the clusters on the respective segment [3].

Each volunteer was asked to perform 5 complete cycles of scaption from the resting position to 120°, marked by an horizontal bar placed at the previously measured height. The task was repeated for each of the following aids in order:

1. Visual demonstration by the operator, considered as no aid;
2. Duct tape placed on the lab floor (Figure 2b);
3. Vertical poles placed onto the virtual extension of the tape (Figure 2b);
4. Novel scapular laser guide positioned over the middle third of the scapular spine (Figure 2a).

During the elevation phase of the cycle, at the humerothoracic elevation angle of 90°, the glenohumeral plane of elevation was measured. The Shapiro-Wilk test was performed on each group to determine normality. Pairwise comparisons of guidance methods were conducted using the Mann-Whitney U test with significance set at $p < 0.05$.

(a) (b)

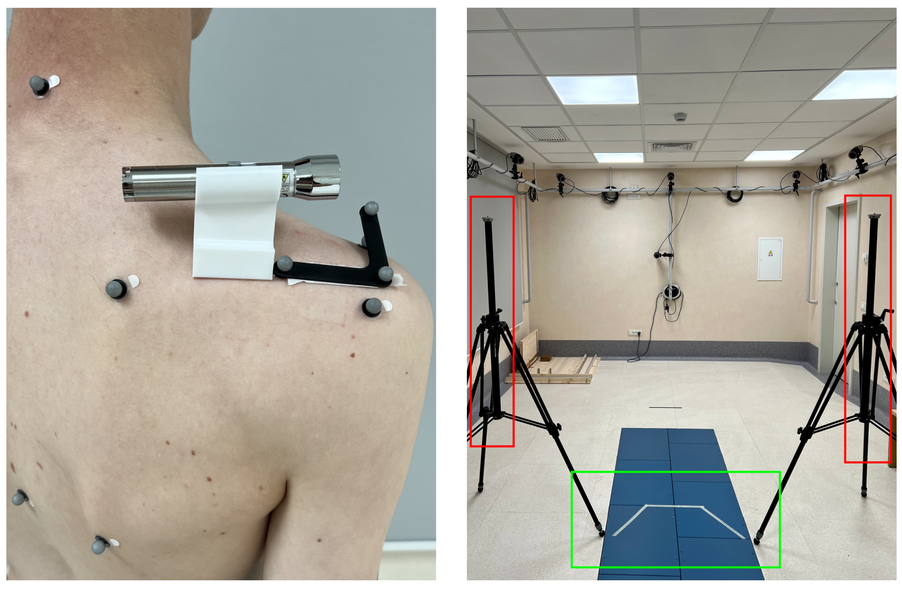

Figure 2: (a) Scapula marker setup with the laser guiding device (white) and AMC (black). (b) Experimental environment with poles (red) and tape (green).

Results and Discussion

From the analysis in Table 1 and Figure 3, laser guiding showed the lowest variability (SD = 13.62°) and a narrower IQR (20.64°), suggesting higher consistency and better inter-subject repeatability compared to the other methods. In contrast, the tape demonstrated the widest IQR (37.31°), showing greater variability and a potentially lower repeatability. Shapiro-Wilk tests revealed that only laser's data followed a normal distribution ($p = 0.116$), while the others significantly deviated from normality ($p < 0.05$). Pairwise comparisons revealed significant differences between Laser and Poles ($p = 1.46 \times 10^{-5}$), Laser and Tape ($p = 0.0045$), None and Poles ($p = 0.0045$), and Poles and Tape ($p = 0.033$) while no significant difference was observed between Laser and None ($p = 0.285$) and between None and Tape ($p = 0.077$). The lack of difference between None and Tape may result from the tape's reference being lost at small elevation angles, causing inconsistent guidance.

Aid	Mean [°]	SD [°]	Median [°]	IQR [°]
Laser	-1.63	13.62	-0.80	20.64
Poles	18.87	19.51	15.79	32.54
Tape	11.90	18.50	10.63	37.31
None	4.85	18.52	-2.04	32.30

Table 1: Mean, standard deviation (SD), median, and interquartile range (IQR) for glenohumeral plane of elevation are reported for each aid method.

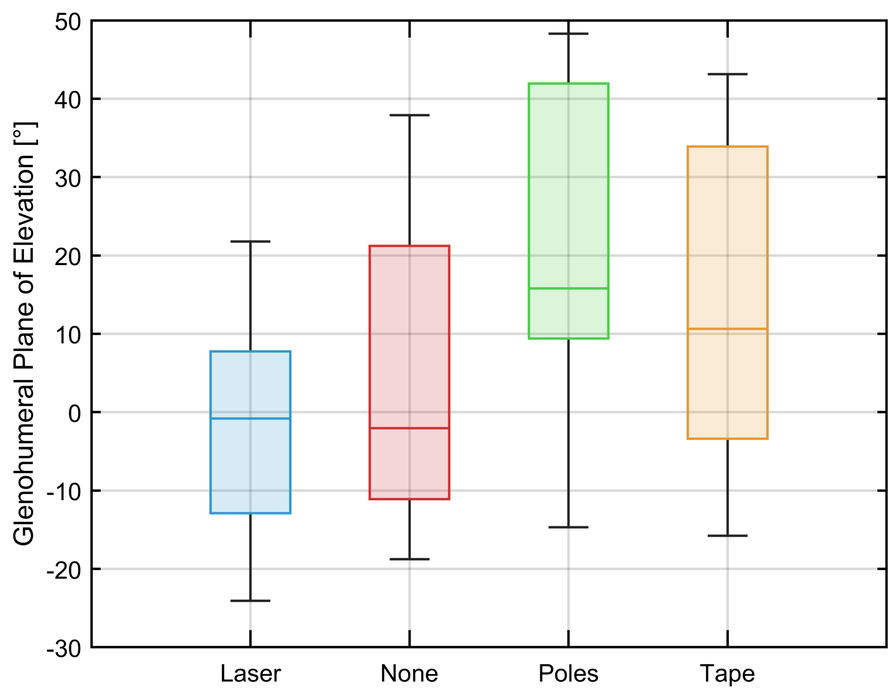

Figure 3: Boxchart of the glenohumeral plane of elevation angle at 90° humerothoracic elevation for the four assistance conditions.

Conclusions and Future Work

The laser guiding device proved to be an effective tool for assisting participants in performing the scaption task with improved repeatability. These preliminary findings support its validity as a low-cost and practical solution for guiding upper limb movements in both clinical and research settings. Further investigations will explore its performance, along with other assistance methods, across multiple humerothoracic elevation angles, considering both dominant and non-dominant limbs, unilateral and bilateral movements, and including the lowering phase of the motion.

References

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