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Upper limb kinematics of an elite climber during a power slap task

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INTRODUCTION:

Climbing coaches can benefit from quantifying upper limb kinematics during climbing activities to develop training programs. However, kinematic analyses of climbing tasks are rare due to technological limitations, and coaching relies on qualitative observation or video data (2). Inertial measurement units (IMUs) are wearable, portable, and require minimal preparation and can be undertaken in real-world settings. However, prior to their widespread use the validity of these tools for climbing tasks warrants investigation. The study aims to quantify upper limb kinematics of an advanced climber during climbing-specific tasks and compare the accuracy of IMU-derived kinematics to optical motion capture.

METHODS:

A male climber (age: 23 years; body mass: 61.1 kg; top boulder grade: V11; climbing experience: 14 years) provided written informed consent to participate in this study. A twelve-camera motion analysis system and five Blue Trident IMUs (Vicon, Motion Systems Ltd) simultaneously acquired kinematic data. Retroreflective markers and IMU sensors were attached to the torso, pelvis, upper arms, and forearms, Following a self-selected warm up the climber performed two repetitions of a power slap test. The test begins with a two-armed hang on a 45mm rung, followed by an explosive pull-up where one arm slaps the scale board above. Upper limb kinematics were calculated using inverse kinematics following the OpenSense workflow (3) within OpenSim 4.4. **RESULTS:**

The mean distance attained during the power slap was 1.0 m for both arms. The dominant hand slap showed higher humeral flexion, abduction, and internal rotation (126.2°, 56.8°, and 45.8°) compared to the non-dominant hand slap (120.6°, 43.6° and 41.9°). Whereas torso lateral flexion and rotation were lower in the dominant hand slap. IMU and optical capture kinematic differences ranged from 1.1° to 7.9°, with the largest occurring in humeral internal rotation.

CONCLUSION:

This work presents novel insights into the upper limb kinematics of a highly explosive climbing task performed by an elite climber. Despite attaining similar heights between dominant and non-dominant limbs during the power slap the climber exhibited differences in upper limb kinematics suggesting slight alterations in coordination. IMU-derived upper limb kinematics were comparable to the optical capture system during both the two-armed hanging position phase and the single-arm slapping phase of the power slap. Despite these promising results further work is necessary to further evaluate the accuracy of IMUs in quantifying upper limb kinematics in climbers which should include a larger sample size and wider array of climbing tasks. The notable asymmetries in upper limb kinematics may provide coaches with additional cues to observe when developing climbers.

References

1. Lutter et al., BJSM, 2021

2. Fuss et al., Sports Eng, 2010

3. Al Borno et al., J. NeuroEng. Rehabil, 2022

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Presentation



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