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Scapula kinematics of pull-up techniques: Avoiding impingement risk with training changes

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ABSTRACT

Objectives: Overhead athletic activities and scapula dyskinesia are linked with shoulder pathology; pull-ups are a common training method for some overhead sports. Different pull-up techniques exist: anecdotally some are easier to perform, and others linked to greater incidences of pathology. This study aims to quantify scapular kinematics and external forces for three pull-up techniques, thus discussing potential injury implications.

Design: An observational study was performed with eleven participants (age = 26.8 ± 2.4 years) who regularly perform pull-ups.

Methods: The upward motions of three pull-up techniques were analysed: palms facing anterior, palms facing posterior and wide-grip. A skin-fixed scapula tracking technique with attached retro-reflective markers was used.

Results: High intra-participant repeatability was observed: mean coefficients of multiple correlations of 0.87–1.00 in humerothoracic rotations and 0.77–0.90 for scapulothoracic rotations. Standard deviations of hand force was low: <5% body weight. Significantly different patterns of humerothoracic, scapulothoracic and glenohumeral kinematics were observed between the pull-up techniques. The reverse technique has extreme glenohumeral internal–external rotation and large deviation from the scapula plane. The wide technique has a reduced range of pro/retraction in the same HT plane of elevation and 90° of arm abduction with 45° external rotation was observed. All these factors suggest increased sub-acromial impingement risk.

Conclusions: The scapula tracking technique showed high repeatability. High arm elevation during pull-ups reduces sub-acromial space and increases pressure, increasing the risk of impingement injury. Wide and reverse pull-ups demonstrate kinematics patterns linked with increased impingement risk. Weight-assisted front pull-ups require further investigation and could be recommended for weaker participants.

1. Introduction

Pull-ups are a common training activity for a range of sports. A link between scapula kinematics and injury, most commonly shoulder impingement, is widely theorized and occasionally tested,[1,2] particularly in overhead activities. Shoulder impingement is the compression of the rotator cuff and subacromial bursa on the anteroinferior aspect of the acromion coracoacromial ligament.[3] This can occur with extreme internal glenohumeral (GH) rotation during unloaded abduction and forward flexion.[4]

Anecdotal evidence indicates that reverse pull-ups are easiest to perform, while wide-grip pull-ups are implicated with higher incidences of shoulder pathology. Climbing and gymnastics, which utilize pull-up-like techniques, are strongly linked to shoulder pathology—particularly shoulder impingement.[5,6] However, there is no quantitative discussion of the scapula and upper limb kinematics, or comparisons of the many different techniques, for pull-ups.

Difficulties in measuring 3-D scapula kinematics, due to skin artefacts, contributed to the lack of quantitative literature. Non-invasive skin-fixed devices with multiple attachment points and optimal calibration have reduced errors at high angles of humeral elevation and throughout the ROM in dynamic tasks.[7,8]

Pull-ups are a closed-chain activity; good motion repeatability is therefore theorized across the experimental group (inter-participant), allowing comparison of group averages. Large muscle contractions in the shoulder have been hypothesized to reduce the consistency of observed joint kinematics.[9] Pull-ups will provide a challenging environment in which to observe the intra-participant repeatability.

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The aim is to present a kinematics dataset that compares the humerothoracic, scapulothoracic, and glenohumeral rotations across three pull-up techniques and discuss potential injury risks associated with these techniques.

2. Methods

A convenience sample of eleven healthy male participants with no history of shoulder pathology participated (age = 26.8 ± 2.4 years, BMI = 22.2 ± 2.2 kg/m^2, height = 1.80 ± 0.06 m). Participants were performing pull-ups as part of a regular training regime (>3 years training experience). The local ethics committee approved this study.

Kinematic data collection utilized 9-camera optical motion tracking (Vicon, UK) at 200 Hz and a force plate (Kistler, Switzerland) at 1000 Hz (Fig. 1). A Scapula Tracker (ST[7]) measured scapula kinematics. The device consists of a base attached to the mid-portion of the scapula spine and an adjustable foot positioned on the meeting-point between the acromion process and the scapula spine. This position is optimal for the attachment of the ST.[8] The ST technical coordinate frame was calibrated with the anatomical coordinate frame of the scapula using the International Society of Biomechanics (ISB) recommended anatomical landmarks[10] and measured directly using a scapula Locator.[8] Calibration was performed at 90° of humerothoracic (HT) elevation at 45° to the coronal plane: the mid-point of the overall motion.[7] The calibration transformation was applied to each trial of that participant. Errors associated with static palpation of landmarks are small (~2°[11]).

Twenty-one retro-reflective markers were used to track the thorax, clavicle, humerus and forearm.[8,10] Elbow epicondyles were defined as a rigid offset from the humerus technical frame with the arm at 90° elevation, 45° from the coronal plane, 90° elbow flexion and a vertical forearm. Least squares sphere-fitting was used

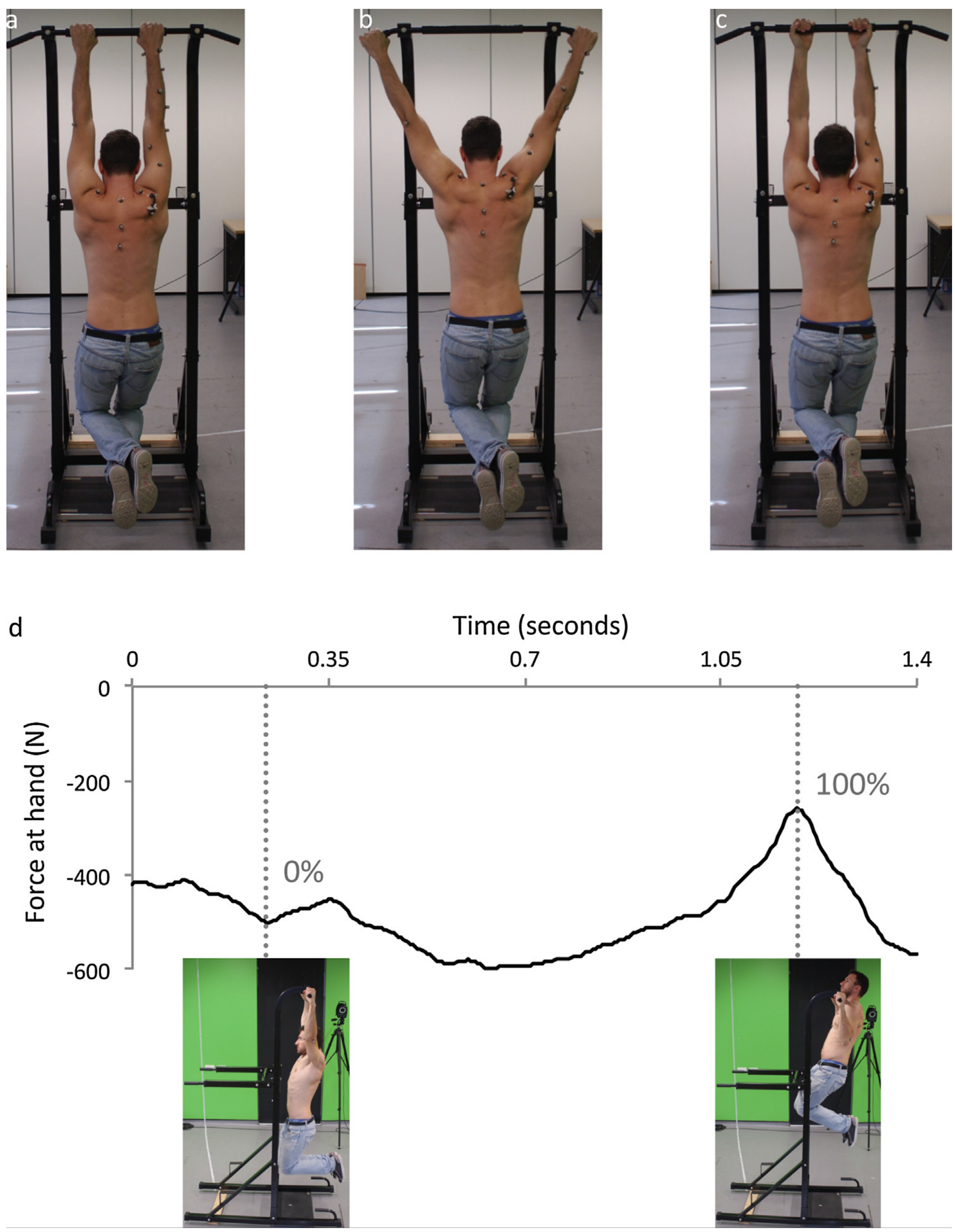

Fig. 1. Experimental set-up showing position of the pull-up frame, force plate and participant. The three pull-up techniques are described: front (a) wide (b) and reverse (c), with the prescribed leg position. Normalization of the data is shown with force at one hand during a pull-up: 0% and 100% of the motion are marked (d). Images illustrate approximate body position at these two points for a representative participant.

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