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Measuring scapular kinematics during arm lowering using the acromion marker cluster

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ABSTRACT

The aim of the present study was to examine the acromion marker cluster (AMC) method of measuring scapular kinematics during the arm lowering, eccentric, phase. Twenty six participants completed arm elevation and lowering in the sagittal, frontal and scapular plane. The participants held their arm at 30° increments while the orientation of the scapula was recorded using an AMC and a scapular locator (SL). There were no significant differences between the AMC and SL during the lowering phase for sagittal and scapular plane arm movements. The AMC significantly underestimated upward rotation (max RMSE = 6.0°), and significantly overestimated posterior tilt (max RMSE = 7.2°) during arm lowering in the frontal plane. The reported root mean square errors, however, were within the ranges observed during the elevation phase and reported in previous literature. The AMC therefore provides a reasonable description of scapular kinematics during the arm lowering phase.

1. Introduction

Abnormal scapular kinematics during arm elevation is evident in patients with shoulder pain (Lin et al., 2005; Ludewig & Cook, 2000; Ludewig & Reynolds, 2009; McClure, Bialker, Neff, Williams, & Karduna, 2004). Shoulder impingement due to reduced sub-acromial space causing compression onto the sub-acromial tissues (Neer, 1972), may be compounded during the lowering, eccentric, phase of movement as winging of the scapula occurs (Boublik & Hawkins, 1993; Warner, Micheli, Arslanian,

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Kennedy, & Kennedy, 1992). Patients with shoulder impingement often report greater pain during the lowering phase compared to the elevation phase (Borstad & Ludewig, 2002; Boublik & Hawkins, 1993), therefore, the lowering phase of arm movement may provide a more valuable clinical examination to detect clinical dyskinesia (Kibler, 1998).

Small and inconsistent findings, however, have been found when examining scapular kinematics during the lowering phase in patients with shoulder impingement (Borstad & Ludewig, 2002; McClure et al., 2004). Slight increases in scapulohumeral rhythm have been found in healthy controls (Bourne, Choo, Regan, MacIntyre, & Oxland, 2007; Braman, Engel, LaPrade, & Ludewig, 2009; McClure, Michener, Sennett, & Karduna, 2001), but results are equivocal (Ludewig et al., 2009). The lack of consistent findings may be attributable to the inherent difficulties in measuring scapular kinematics. The scapula primarily glides along the posterior thoracic wall beneath the skin surface (Veeger & van der Helm, 2007), therefore, skin mounted reflective markers over the scapula's bony landmarks do not adequately track the scapula (Lempereur, Brochard, Burdin, & Remy-neris, 2010; Lovern, Stroud, Evans, Evans, & Holt, 2009). To overcome this issue different methodologies have been adopted, including the use of bone pins which provide a direct measure of the scapula's movement but are invasive. Imaging of the scapula exposes the participant to ionizing radiation and is open to errors based on the projection of three-dimensional movement onto a two-dimensional plane (de Groot, 1999), unless complicated bi-planar imaging techniques are used. Manual palpation of the scapula is non-invasive but is time-consuming and open to sources of error due to the repeated manual identification of the scapula (van der Helm & Pronk, 1995). A modification of manual palpation is the Scapular Locator device (SL), proposed by Johnson, Stuart, and Mitchell (1993). The SL aimed to reduce data collection time by making a rigid-body assumption of the scapula and uses a fixture with three fixed points to make simultaneous recordings of the scapula's bony landmarks. The SL was recently coined as the 'silver standard' by the International Shoulder Group in the absence of a suitable gold standard for obtaining scapular kinematics (Cutti & Veeger, 2009). The SL method is limited, however, due to the static nature of the measurements, the relative subjective positioning of the device, and the participant receiving proprioceptive feedback on the location of their scapula making it unsuitable for use during clinical movement tests.

The acromion method, where an electromagnetic sensor or cluster of markers is placed over the flat portion of the acromion (McQuade & Smidt, 1998), offers an alternative. The advantages of the acromion marker cluster (AMC) are that it provides continuous data throughout the movement, enabling a more comprehensive evaluation of scapular kinematics, and does not require intervention from the investigator during recordings. Although the acromion provides the least amount of skin movement artefact compared to other sites on the scapula (Matsui, Shimada, & Andrew, 2006), the AMC is still open to error due to skin slipping over the top of the acromion. Factors that may affect this are sub-cutaneous tissues and muscle mass altering the relationship between the skin and acromion, which may differ between males and females, making gender a confounding factor affecting the validity of the AMC.

The AMC has been shown to be valid up to 120° of arm elevation (Karduna, McClure, Michener, & Sennett, 2001; Meskers, van de Sande, & de Groot, 2007; van Andel, van Hutten, Eversdijk, Veeger, & Harlaar, 2009), but has not been validated during the lowering, eccentric, phase of arm movement. If scapular kinematics during the arm lowering phase is to be examined in patients with shoulder impingement it is vital that the validity of the AMC is established, and in addition, factors are determined that may affect the validity of the AMC (e.g., gender). The aim of this study, therefore, was to compare AMC measurements of scapular kinematics to the 'silver standard' SL during the arm lowering phase. A secondary aim was to determine if gender had an influence on the validity of the AMC.

2. Method

2.1. Participants

Twenty six participants (11 males and 15 females) were recruited from staff and students of the University of Southampton (Table 1). The dominant arm was used throughout testing. This was the right arm for all participants, except one who was left hand dominant.