A PRELIMINARY ELECTROMYOGRAPHIC INVESTIGATION INTO SHOULDER MUSCLE ACTIVITY IN CRICKET SEAM BOWLING

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The aim of this investigation was to describe and compare surface electromyographic activity of shoulder musculature during cricket seam bowling between two elite bowlers with (bowler A) and without (bowler B) shoulder pathology. Activity of seven muscles were recorded at 500 Hz with a digital camera sampling at 210 Hz used to define phases within the movement. Whilst both the duration of the movement and ball velocity were similar between bowlers (bowler A: duration = 0.89 ± 0.04 s, ball velocity = 27.08 ± 1.21 $m.s^{-1}$; bowler B: duration = 0.72 ± 0.02 s, ball velocity = 26.59 ± 1.49 $m.s^{-1}$), variations in muscle activity particularly for biceps brachii and infraspinatus were established. Further research utilising larger sample sizes is required to establish if such variations occur as a consequence of shoulder pathology or if these are due to other contributing factors.

KEYWORDS: EMG, KINETICS, INJURY, CRICKET, ROTATOR CUFF

INTRODUCTION: Shoulder injury prevalence amongst seam bowlers has been reported at 0.9% with consensus amongst researchers that current injury definitions grossly underestimate the true occurrence (Bell-Jenje & Gray, 2005; Ranson & Gregory, 2008). Similar to other overhead athletes, bowlers have been found to exhibit altered joint range and strength associated with internal and external shoulder rotation which may impair the ability of the surrounding musculature to stabilise the joint and prevent migration of the humeral head during deceleration (Aginsky *et al.*, 2004; Giles & Musa, 2008). Whilst altered surface electromyography (sEMG) activity, particularly that of biceps brachii has been associated with shoulder pathology in other sports (Glousman *et al.*, 1988), to date, minimal research has been undertaken to quantify the activation profile of surrounding shoulder musculature during bowling. The aim of this preliminary investigation was to first, describe sEMG activity of the shoulder during the bowling delivery, and second, to compare sEMG activity between two bowlers with and without the presence of shoulder pathology.

METHOD: After gaining university ethical approval, two county medium-fast seam bowlers were recruited and provided informed consent. These bowlers were selected due to displaying similar anthropometric characteristics and both were previously classified by coaching staff as bowling with a semi-open technique. Bowler A (age: 35 years, height: 1.83 m, mass: 76 kg) exhibited a clinical history of injury afflicting his bowling shoulder with an associated change in joint range of motion (internal rotation at 90° abduction: 70°, external rotation at 90° abduction: 125°). In comparison, bowler B (age: 19 years. height: 1.85 m, mass: 67 kg) had no history of injury affecting his bowling shoulder and displayed near symmetrical joint range of motion.
All testing was conducted at the Sussex County Cricket Club Indoor School. sEMG activity of seven muscles (infraspinatus, supraspinatus, anterior deltoid, middle deltoid, posterior deltoid, biceps brachii and triceps brachii) were recorded at 500 Hz using a radio telemetry system (MIE Medical Research Ltd, Leeds, UK). Following skin preparation, AgAgCl surface electrodes were placed in accordance with (Cram *et al.*, 1998), with a maximal voluntary contraction (MVC) recorded against manual resistance for each muscle under investigation. To assist in defining phases of the delivery stride and quantifying ball velocity at release, a digital camera (Casio Exilim EX-FH20 ,Casio, UK) sampling at 210 Hz was positioned parallel to the bowling crease. To enable temporal synchronisation between sEMG and kinematic data, a footswitch was placed in the bowler's footwear to establish front foot contact (FFC).

Following a self-selected warm up, bowlers were instructed to bowl fifteen deliveries at varying lengths to simulate match conditions. After every delivery, bowlers were requested to assess their action to ensure that it was reflective of their normal bowling technique.

The raw sEMG signal was visually appraised to determine its suitability for analysis where two trials for bowler B were excluded from further analysis due to excessive noise. Subsequently all data were imported into a custom program created using Labview 2009 (National Instruments, Austin, USA) where for the purpose of analysing the bowling action, the delivery was divided into four phases. The first phase, pre-delivery stride to back foot contact (PDS to BFC) was signified by the commencement of rotation of the arm during the pre-delivery stride until back foot contact (BFC). The period between BFC and FFC defined the second phase (BFC to FFC), which was followed by the third phase occurring between FFC and the instant of ball release (FFC to BR). The end of the bowling action was defined by the fourth phase, from ball release until follow through, where the bowling arm ceased to rotate (BR to FT). After determination of FFC, the raw signal was rectified and filtered using a low pass filter to create a linear envelope, where it was expressed as a percentage of the MVC value for each muscle. To establish the role of the selected muscles towards both performance and shoulder joint stability throughout the bowling action, muscle activity for each individual muscle, during each phase was analysed in relation to the contribution of average activity and peak muscle amplitude. Average muscle activity was quantified through integration of both MVC and dynamic trials for each muscle using trapezoid rule to provide a standardised measure of the contribution of average activity during each phase in relation to average activity during the entire bowling action. Differences in delivery ball speed and the influence this would impart on muscle activity were accounted for by expressing both peak and average muscle activity values as a percentage of ball velocity.

Statistical analysis was undertaken using SPSS version 17 for windows (SPSS inc., Chicago, USA). Inter-bowler and within-bowler consistency was quantified using the coefficient of variation (CV). To avoid violations of statistical assumptions, comparisons between bowlers were performed using descriptive statistics.

RESULTS AND DISCUSSION: A graphical representation of the mean muscle activity during the delivery stride for each bowler can be seen in Figure 1, where bowler A typically demonstrated greater muscle activity throughout the movement. For all trials the duration of the bowling action and ball velocity were similar between bowlers (bowler A: duration = 0.89 ± 0.04 s, ball velocity = 27.08 ± 1.21 $m.s^{-1}$; bowler B: duration = 0.72 ± 0.02 s, ball velocity = 26.59 ± 1.49 $m.s^{-1}$). The CV values for each muscle between bowlers ranged from 16.4 to 22.4 %, indicating variability between bowler's techniques. Within-bowler CV values for bowler A ranged between 4.6 to 12.1 % and bowler B 11.1 to 17.9 %. Further research utilising more bowlers would be required to ascertain if within and between-bowler variability is reflective of adaptations due to shoulder pathology or if it is indicative of other factors such as bowling experience.

PDS to BFC: Whilst for both bowlers this phase was found to temporally constitute the majority of the bowling action (bowler A: 40 ± 3 %, bowler B: 36 ± 4 %), the contribution of the bowling arm is minimal with the main emphasis during this phase of the movement is for the bowler to successfully convert momentum gained during the run-up from the lower body and trunk to contribute towards ball velocity. This was supported by low average muscle activity for the majority of muscles for with the largest contributors coming from the triceps brachii (bowler A: 37.0 ± 7.0 %, bowler B: 32.8 ± 6.5 %) and posterior deltoid (bowler A: 34.3 ± 5.3 %, bowler B: 34.5 ± 5.4 %), which aid in extension at both the shoulder and elbow as the arm commences clockwise rotation.

BFC to FFC: During this phase the arm continues to rotate clockwise to coincide with being close to horizontal at FFC. This phase of the movement accounted for 25 ± 1 % (bowler A) and 22 ± 2 % (bowler B) of the bowling action, which was characterised by an increase in muscle activity for both bowlers relative to the initial phase. Whilst only minimal changes were associated with bowler A, greater changes in the contribution of average muscle activity for infraspinatus (27.7 ± 3.6 %), supraspinatus (27.9 ± 2.6 %) and posterior deltoid (38.1 ± 5.1 %) were associated with bowler B.

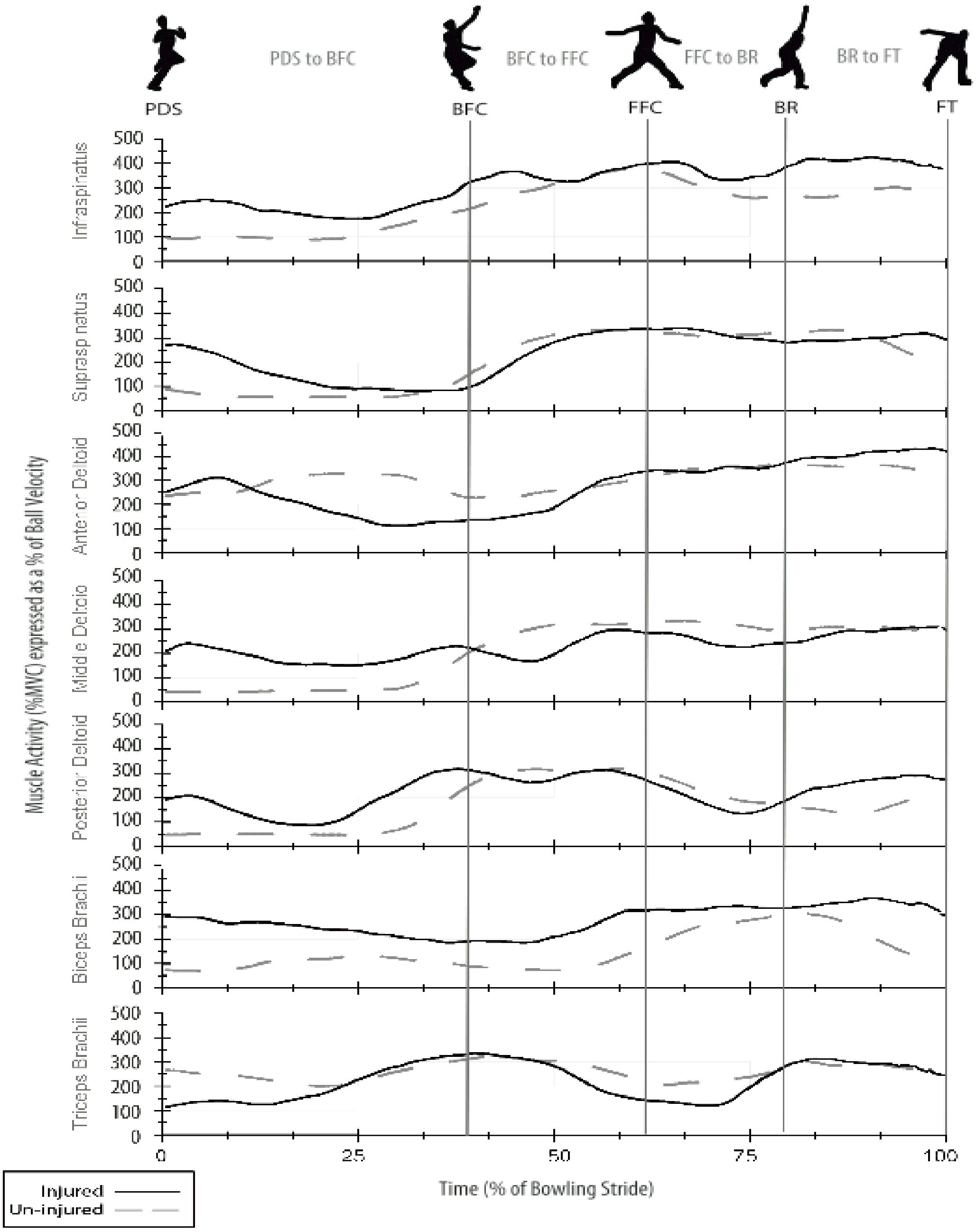

Figure 1. Graphical representation of muscle activity during the delivery stride for bowler A (injured) and bowler B (un-injured)

FFC to BR: This phase of the movement is typified by continued clockwise rotation of the arm in an externally rotated position ending at ball release when the arm is close to the vertical. Although the shortest phase in duration (bowler A: 13 ± 1 %, bowler B: 18 ± 1 %), there were large contributions in peak muscle activity particularly for infraspinatus (bowler A: 424 ± 36 %, bowler B: 408 ± 49 %) and middle deltoid (bowler A: 291 ± 37 %, bowler B: 353 ± 24 %).

BR to FT: During this phase, equating to 21 ± 2 % (bowler A) and 24 ± 2 % (bowler B) of the bowling action, the momentum achieved during the earlier phases causes the arm to continue to rotate through both flexion and adduction at the shoulder towards the final position around the contralateral hip. The focus of the musculature surrounding the shoulder is to control the deceleration of the arm typified by surrounding muscles either eccentrically or concentrically contracting to aid in both arresting the movement and stabilising the joint. Both bowlers demonstrated high contributions of average and peak muscle activity, particularly for infraspinatus (bowler A: peak: 477 ± 54 %, average: 26.6 ± 4.8 %; bowler B: peak: 334 ± 106 %, average: 28.6 ± 4.2 %), anterior deltoid (bowler A: peak: 462 ± 37 %, average: 30.1 ± 4.9 %; bowler B: peak: 403 ± 53 %, average: 28.4 ± 3.9 %) and biceps brachii (bowler A: peak: 397 ± 35 %, average: 25.7 ± 5.2 %; bowler B: peak: 324 ± 49 %, average: 37.0 ± 7.2%).

Throughout the bowling action, variations in muscle activity were observed between bowlers. Whilst there are a multitude of factors that may account for this such as the age and bowling experience of the bowlers analysed, such variation could also occur as a consequence of shoulder pathology. Bowler A demonstrated higher levels of muscle activity particularly for both infraspinatus and biceps brachii, which Glousman *et al.* (1988) postulated may be reflective of a greater reliance on surrounding musculature to maintain joint integrity. The complexity of the joint and the role of surrounding musculature warrant further investigation utilising both kinematic and kinetic techniques to establish the relative contributions of muscle activity towards both bowling performance and joint integrity.

CONCLUSION: Preliminary findings from this study aid in establishing the contribution of shoulder musculature throughout the bowling delivery with variations in muscle activity observed between bowlers with and without the presence of shoulder pathology. Before such findings can be applied, further investigation incorporating larger sample sizes is required first, to substantiate how individualised execution of the bowling action is, and second, to quantify contributions individual muscles have on shoulder joint forces during this dynamic movement.

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