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CRICKET SIDE STRAIN INJURIES: A DESCRIPTION OF TRUNK MUSCLE ACTIVITY AND THE POTENTIAL INFLUENCE OF BOWLING TECHNIQUE

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The aim of this research was to investigate the muscle activity of internal oblique and external oblique during the bowling action due to their association with side strain injuries in cricket fast bowlers. Six professional County fast bowlers of differing techniques (side-on (n=2), mixed (n=1) and semi-open (n=3), bowled three deliveries with sEMG of both internal oblique and external oblique on the side contralateral to the bowling arm recorded at 500 Hz. Findings indicate that peak muscle activity for both internal and external oblique, though of similar magnitude, differed in timing. This may be associated with the moment of side strain injury during the bowling action, which has not yet been described. Preliminary data suggests this timing appears to vary according to the bowler's technique. Further investigation incorporating upper limb and trunk kinematics is required.

KEY WORDS: Electromyography, internal oblique, injury, abdominal.

INTRODUCTION: Cricket injury surveillance research in Australian first class cricket has reported that side and abdominal strains account for the second highest seasonal incidence and fourth highest prevalence of all body areas for the three seasons to 2008/2009 (Orchard *et al.,* 2010). All side strain injuries to bowlers described within the literature affect the side contralateral to the bowling arm, with all but one injury affecting internal oblique (IO) or external oblique (EO) (Connell *et al.,* 2003; Humphries and Jamison, 2004).
It has been postulated that the probable point of IO rupture in side strain injuries in cricket bowlers is the sudden vigorous motion from assumed maximum eccentric contraction when the non-bowling arm is fully flexed and then suddenly extends or pulls through, allowing the bowling shoulder to flex to bowl the ball (Connell *et al.,* 2003). The fast bowling technique is classified into four distinct styles: side-on, semi-open, front-on or mixed, according to the relationship between the planes of the hips and shoulders, and shoulder counter-rotation during the bowling action (Portus *et al.,* 2004). Whilst Portus *et al.* (2004) investigating 42 elite fast bowlers correlated the risk of lumbar stress fracture to the mixed bowling technique, no significant relationship was established between technique factors and side strain injury within this group of bowlers.
However, to date no research has been undertaken to determine if the respective bowling classification types affect the activity patterns of IO and EO; muscles reportedly injured on imaging in side strain throughout the fast bowling action. Therefore, the aim of this preliminary investigation was to utilise surface electromyography (sEMG) to describe the muscle activity of IO and EO observed during delivery stride of the fast bowling action in a small group of professional bowlers and the potential influence of technique on peak and average sEMG amplitudes of these muscles.

METHODS: After gaining university ethical approval, six professional County fast bowlers (24.50 ± 5.54 years, 1.86 ± 0.04 m and 84.33 ± 9.85 kg) were recruited. Bowlers had been previously assessed as bowling with side-on (n=2), mixed (n=1) and semi-open (n=3) techniques according to the definitions of Portus *et al.* (2004). Following an explanation of the experimental aims and procedures all participants provided informed consent. Inclusion criteria required that bowlers were deemed fit to bowl at maximal effort by the club physiotherapist.
Data collection was conducted at the indoor school at Hampshire County Cricket Club allowing bowlers to bowl using their normal run-up onto a standard size, artificial wicket. sEMG activity of the selected trunk musculature were recorded at 500 Hz using a radio

telemetry system (MIE Medical Research Ltd, Leeds, UK) and synchronised to 100 Hz Basler cameras using a MX Ultranet control unit (Vicon, Los Angeles, USA) to enable visual determination of bowling delivery phases.
Following skin preparation in accordance with Payton and Bartlett (2008), AgAgCl surface electrode pairs with an inter-electrode distance of 5cm were positioned parallel to the muscle fibres of the selected muscles under investigation. Following the modified guidelines of McGill *et al.,* (1996), electrode pairs were placed 5cm medial to the anterior superior iliac spine (IO) and 15cm lateral to and at the transverse level of the umbilicus (EO).
Following an adequate warm up and habituation with the testing environment, participants were instructed to bowl three deliveries at match pace. Each delivery was subjectively assessed to ensure it was representative of the bowler's technique.
The raw sEMG signal was visually appraised to determine its suitability for analysis and then processed using a linear envelope with a frequency of 6 Hz (Winter, 1990) within Vicon Motus 9.2 software (Vicon, Los Angeles, USA) where it was expressed as a percentage of the dynamic maximal voluntary contraction (MVC). Dynamic MVC values for each bowler were established from the peak muscle amplitude observed during all recorded deliveries to provide a movement specific maximal value. All data were then exported into a custom program using Labview 2009 (National Instruments, Austin, USA) for further analysis where using the synchronised video footage the bowling delivery was temporally divided into five phases and subsequently normalised to account for variations between deliveries and bowlers (Payton and Bartlett, 2008). The first phase was defined as occurring from back foot contact to maximum elevation of the non-bowling arm (BFC to Arm max). The period in which the non-bowling arm lowered from its elevated position was defined by two phases, namely when the arm lowered to be perpendicular to the trunk (Arm max to Arm 90º), and, from the arm being perpendicular to the trunk to front foot contact (Arm 90º to FFC). The final phases of the delivery stride were defined from front foot contact to ball release (FFC to BR) and from ball release to follow through where the bowling arm ceased to rotate towards extension (BR to FT).
To investigate the relative demands of the lateral trunk musculature during the bowling action, muscle activity of IO and EO was described in relation to average muscle activity during each bowling phase and peak muscle activity during the entire delivery. To avoid violations of statistical assumptions owing to the small sample size, the influence of seam bowling technique on trunk muscle activity was investigated using descriptive statistics.

RESULTS AND DISCUSSION: A graphical representation of the trunk muscle activity during the bowling delivery stride can be seen in Figure 1. Differences in both average and peak muscle activity can be observed between different bowling techniques. Due to the small sample size in this investigation, further research with a much larger sample would be required to substantiate these observed patterns as being resultant of bowling technique and not due to individualised factors such as age, bowling speed and experience. This sample also had a relatively very small representation of mixed technique bowlers (n =1) in contrast to previous research (Portus *et al.,* 2004).
For both side-on and mixed techniques, higher average EO muscle activity was observed during BFC to Arm max (side-on: 73.68 ± 11.27%MVC, mixed: 85.13 ± 11.89%MVC) and Arm max to Arm 90º (side-on: 76.92 ± 12.28%MVC, mixed: 63.43 ± 4.52%MVC). In comparison, semi-open bowlers displayed lower average muscle activity during BFC to Arm max of 47.28 ± 11.00%MVC, with higher average muscle activity observed during both Arm max to Arm 90º (64.26 ± 15.66%MVC) and Arm 90º to FFC (61.64 ± 18.4%MVC). In comparison, average IO muscle activity was observed to be similar regardless of bowling technique during the earlier phases of the delivery, with an increase in average muscle activity observed during FFC to BR for both side-on (75.68 ± 9.02%MVC) and mixed bowlers (89.63 ± 1.10%MVC) which was almost twice the average activity observed for EO during the same phase (side-on: 43.30 ± 4.40%MVC, mixed: 37.77 ± 8.15%MVC). Higher average IO activity observed within this study, especially between FFC and BR, may explain the

predominance of IO injuries documented within previous research (Connell *et al.,* 2003; Humphries and Jamison, 2004).

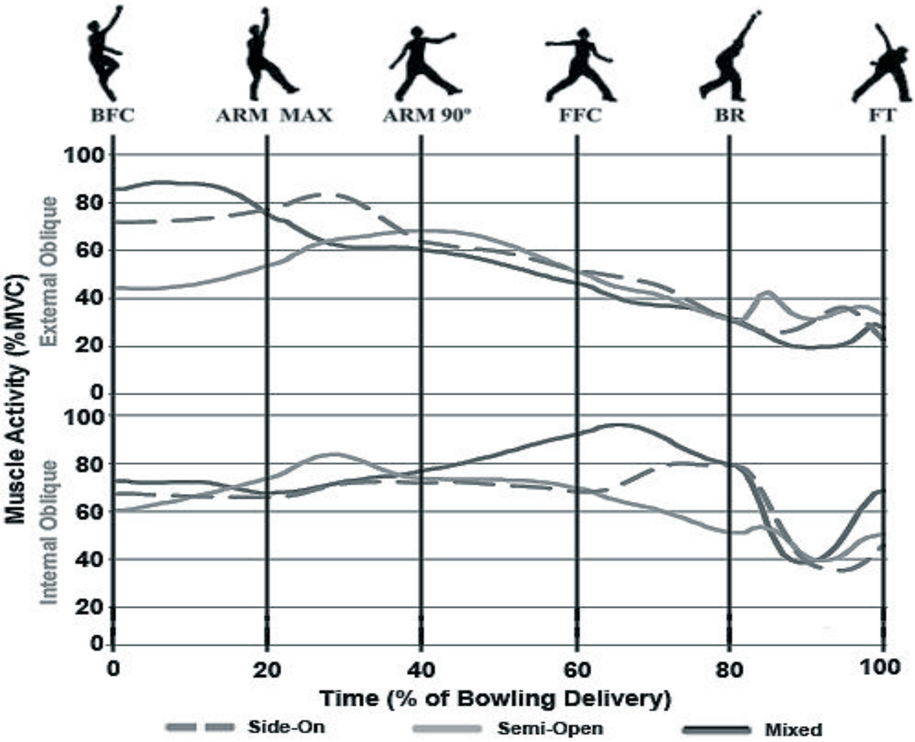

Figure 1: Graphical representation of normalised average trunk muscle activity during the delivery stride.

Whilst the magnitude of peak muscle activity for both IO and EO were similar regardless of seam bowling technique, the timing of occurrence during the bowling action was observed to differ (Table 1). For both side-on and mixed bowling techniques peak EO activity occurred during BFC to Arm max, whilst the semi-open technique was associated with a later peak occurrence during Arm max to Arm 90º. Greater time differences in peak activity were associated with IO. The earliest peak activity was observed for semi-open bowlers during BFC to Arm max, followed by mixed bowlers (Arm max to Arm 90º) and finally side-on bowlers (Arm 90º to FFC).

Table 1
Peak trunk muscle activity (mean ± SD) observed during the bowling delivery stride

Muscle	Technique	Peak Muscle (%MVC)	Time (%)	Phase
External Oblique	Side-on	86.29 ± 3.51%	10.76 ± 0.17%	BFC to Arm max
	Semi-open	82.23 ± 10.59%	25.19 ± 10.61%	Arm max to Arm 90º
	Mixed	90.57 ± 14.56%	7.43 ± 4.45%	BFC to Arm max
Internal Oblique	Side-on	92.25 ± 5.20%	50.64 ± 15.62%	Arm 90º to FFC
	Semi-open	95.33 ± 0.26%	17.27 ± 9.08%	BFC to Arm max
	Mixed	96.53 ± 3.23%	39.35 ± 1.18%	Arm max to Arm 90º

The findings of this investigation suggest that bowling technique does affect the patterns of average muscle activity of EO and IO during the bowling action. It also appears that peak muscle activity of IO is higher for each action classification than the peaks reached by EO. This higher demand may explain the predominance of IO strains reported in earlier research (Connell *et al.,* 2003; Humphries and Jamison, 2004). However, this data is unable to determine the likely moment/s that side strain is sustained during the bowling action since sEMG alone is unable to discriminate between eccentric and concentric muscle activity, and specifically the transition between them. An inference from this data may be that IO activity peaks for side-on and mixed technique bowlers at a moment later than that suggested by Connell *et al.* (2003), at which time the trunk is rotating and side flexing with IO acting concentrically. Contrastingly, semi-open bowlers reach peak IO activity at a moment which may be consistent with the theory of Connell *et al.* (2003). Whilst findings from this investigation provide insight into the influence seam bowling technique may impart on the mechanism of side strain injuries they do not imply that any particular technique classification would have a greater predisposition to side strain injury. Future research needs to be directed towards repeating sEMG data collection on a larger sample in conjunction with upper limb and trunk kinematic analysis.

CONCLUSION: This preliminary investigation is the first to be published which utilises sEMG to describe the muscle activity of IO and EO during delivery stride of the fast bowling action and the potential influence of technique on peak and average sEMG amplitudes of these muscles. The findings of this research suggest that bowling technique does affect the patterns of average muscle activity of EO and IO during the bowling action, though their magnitudes are similar. Average and peak IO muscle activity was found to be greater than that of EO, which may explain the predominance of side strain injuries affecting IO reported in earlier research (Connell *et al.,* 2003; Humphries and Jamison, 2004). For both side-on and mixed techniques peak IO activity occurred much later in the bowling action than for EO. Future research aiming to correlate sEMG activity of IO and EO with upper limb and trunk kinematics in a much larger sample is required. The findings of such research have potential implications for the clinical assessment, rehabilitation and attempted prevention of side strain injuries in professional cricket.

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