ORIGINAL RESEARCH ARTICLE

Incidence, nature and risk factors in shoulder injuries of national academy cricket players over 5 years – a retrospective study

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Abstract

Objective. A strong preventative approach is advocated in order to decrease injury rates and increase performance levels in cricket. However, there are no data on the aetiology of shoulder injuries in the elite cricketer. The aim of this study was to identify possible injury risk factors that may predispose the elite cricketer to injury or re-injury of the shoulder.

Design. Over a 5-year period, cricketers were selected to attend an annual 5-month programme at a National Cricket Academy and underwent a thorough pre-academy postural and biomechanical analysis. A retrospective study was undertaken to investigate the shoulder injuries and the pre-academy assessment findings. The analysis was undertaken by physiotherapists.

Results. A total of 165 injuries amongst 96 cricketers were recorded in this 5-year period. Of these, 40 were shoulder injuries. Eighteen cricketers had experienced a previous (recurrent) shoulder injury. Bowlers and all-rounders collectively sustained 78% of shoulder injuries, with 50% of injuries occurring with fielding activities. Forty-three per cent of the shoulder injuries were assessed as having an associated cervical component. Of the cricketers who were injured or re-injured during the academy, 42% had weak scapular stabilisers, 21% positive upper limb neural tension tests, and 37% limited glenohumeral internal rotation at the pre-academy assessment, prior to injury. Furthermore, 63% had a scoliosis, and 47% a leg length difference (LLD) ≥ 1.0 cm.

Conclusions. A history of a previous shoulder injury was highlighted as an important predictor of future injury for shoulder injuries in cricketers. Further risk factors include player speciality, weak scapular stabilisers, scoliosis and a LLD ≥ 1.0 cm. It is recommended that cricketers undergo a thorough pre-season postural and biomechanical analysis to identify potential injury risk factors in order to prophylactically correct these to minimise the risk and cost of future injury.

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Introduction

Modern first class cricket reportedly places more demand on the elite cricketer than in previous years.[15, 24,29] This is due to an increase in competitiveness, a longer season and modifications in technique and style that aim to achieve a higher level of technical skill.[29] Consequently an increase in the number of injuries to the first-class cricketer has been noted, which arguably may prevent the strongest team from being fielded.[15,24] Ever-increasing pressures placed upon the medical team may result in injured players who are not fully match fit or rehabilitated returning to competition too early which may account for injury recurrence during the season.[24]

There is a growing pool of data available investigating the incidence and nature of epidemiological injuries in the elite cricketer.[15, 24,25] In an epidemiological study conducted on South African cricketers over 2 seasons, Stretch[24] found that the back and trunk (24.7%) and lower limbs (49.9%) were most commonly injured. Upper limb injuries only accounted for 20.4%. Twenty-five per cent of upper limb injuries involved the glenohumeral joint. In a study to investigate the incidence, nature and site of acute injuries sustained by professional English cricketers at a county club over a 10-year period, the lower limb was found to be most frequently injured (44.9%), followed by the upper limb (29.4%) and the trunk (20%). The shoulder accounted for 7.1% of upper limb injuries.[15]

Despite the availability of data pertaining to overall injury incidence, evidence-based information on specific injuries in cricket is scarce. To date, no author has investigated the incidence or nature of shoulder injuries in the elite cricketer. In contrast, much has been written on shoulder injuries in the overhead athlete, especially the thrower's shoulder.[8, 10, 13] Shoulder impingement injuries are currently classified as either primary or secondary impingements.[1,7,11,28] Cumulative microtrauma sustained by the subacromial tissue during overuse and repetitive overloading is the proposed cause of primary impingement.[1,28] Secondary impingement is often found in athletes who participate in sports that require frequent overhead activity,[1] and is associated with primary instability or laxity in the glenohumeral joint capsule.[7] Common clinical findings associated with secondary shoulder impingement include posterior capsule tightness, decreased internal rotation range of motion (ROM), and abnormal scapulohumeral rhythm.[1,28]

Role of the scapula in the thrower's shoulder

The role of the scapular stabilisers in the prevention of shoulder dysfunction is to position and control the movements of the scapula during normal upper limb function.[1,8,10,11,13,18,20] The rest position for the scapula is between elevation and depression, not in protraction, but 30 degrees from the frontal plane, in upward rotation, and with the medial border and inferior angle flat against the chest wall.[18]

Clinically abnormal scapula positioning is associated with poor cervico-thoracic and lumbar postures.[11,18] A typical dysfunction pattern is when the scapula adopts a protracted and downwardly rotated position. This may increase tension and irritation on the upper limb neural system. It is also associated with an increased risk of impingement and increased laxity of the anterior glenohumeral structures, because of the increased stresses imparted to the anterior capsular structures.[11,18]

The upper fibres of trapezius, lower fibres of trapezius and serratus anterior work as a force couple to produce upward rotation of the scapula as a means to minimise impingement and facilitate optimal glenohumeral congruency.[13,18] It appears that these muscles are the most susceptible to inhibition by microtrauma-induced strain or pain around the shoulder and are therefore implicated in the early phases of shoulder dysfunction.[13] Weakness or fatigue of the serratus anterior muscle can result in winging of the vertebral border and tipping of the inferior angle of the scapula. With scapulothoracic fatigue or weakness, disruption of the scapulohumeral rhythm can be observed, the acromion may not be elevated sufficiently to allow passage of the rotator cuff underneath the coracoacromial arch, decreasing the subacromial space resulting in impingement as the end result.[9,11,13]

Biomechanical assessment considerations

Optimal posture is defined as a state of balance that protects the supporting structures against injury or progressive deformity allowing for optimal joint position and joint efficiency.[19] The lordosis, lordosis-kyphosis, flat back and sway back postures are well-described abnormal postural types.[2,12,19,30] They are associated with well recognised differences in length/ tension of synergistic muscles, a contributing factor to compensatory motion and the development of movement impairment syndromes.[23]

Leg length discrepancies (LLD) of between ≥ 5 mm and ≥ 10 mm (1 cm) have been found to negatively impact the spine and lower extremities. Lumbar spine, hip and knee degenerative changes have been described.[6] The importance of evaluating the presence of a LLD in shoulder problems as part of the kinetic chain has been identified.[13,14] The clinical measurement of LLDs by palpation and visual estimation of relative iliac crest height has poor reliability in LLDs of ≤ 1 cm, but is commonly used in a clinical setting.[6]

The upper limb tension test (ULTT) has been termed the straight leg raise test of the arm. ULTTs are recommended in the assessment of all patients with thoracic, cervical, shoulder and other upper limb problems,[3] especially if the origin of the symptoms is unclear from routine examination. Poor scapular position and posture can result in altered neurodynamics of the upper limb neural tissue.[3,18]

Cervical spine mobility is inherently linked to movement of the shoulder girdle.[7,16] Unilateral elevation of the upper extremity produces rotation of the mid and lower cervical spine, to the side of humeral elevation, with counter-rotation of the atlanto-axial joint to the contralateral side. Repetitive bombardment from continuous overhead activities can lead to transverse tears in the cervical discs and hypermobility of the facet joints.[16] Nerve root involvement may be caused by friction or traction of the nerve root by osseofibrous irregularities. The C4 nerve root is responsible for active shoulder girdle elevation.[22]

The factors described above support the premise that a comprehensive and global assessment of postural, biomechanical and neurodynamic influences, as well as other joints proximal and distal to the injured area, is necessary for patients with shoulder dysfunction [7,9,13,17,18,20,21] In the clinical setting most evaluation is qualitative and indirectly assessed by observing posture, the quality of active movements and any abnormalities in muscle recruitment patterns.

Advances in sports medicine have traditionally been governed by improvements in the diagnosis, treatment and rehabilitation of injuries. It is now recognised, however, that a strong preventative approach is needed in order to decrease injury rates and increase performance and participation levels.[5,24]

Due to the high incidence of shoulder injuries occurring over a 5-year period in a National Cricket Academy, a study was undertaken to retrospectively analyse these injuries and the pre-Academy assessment findings. The aim of this study was to identify injury risk factors that predispose the elite cricketer to injury or re-injury of the shoulder obtained from a postural and biomechanical assessment. A further aim was to investigate the nature of shoulder injuries sustained by the elite cricketer over 5 years at the National Cricket Academy.

Methods

All cricketers who attended the National Cricket Academy underwent a comprehensive postural analysis and biomechanical assessment. Data were collected over a 5-year period. The assessment protocol used for this purpose was consistent throughout the 5 years. The assessments were conducted by the investigator and 3 additional physiotherapists. All physiotherapists had received individualised training by the primary investigator with respect to the assessment procedure.

The standardised assessment form included a questionnaire that each cricketer completed at the start of the Academy in order to establish his age, speciality, arm dominance and injury history. This included the presence of pre-existing injuries, history of recurrences, mechanisms of injury, and management of those injuries prior to attending the Academy. An injury was defined as any pain that prevented that cricketer from completing a particular practice, match or training session and caused the player to seek medical attention.[25] The nature of the injury was determined by evaluating the findings of the subjective and objective assessment. As such the diagnosis is a clinical diagnosis.

A pre-existing shoulder injury was defined as any shoulder injury that the cricketer presented with to the Academy, which was currently painful and required treatment. A recurrent shoulder injury was when the cricketer reported at least 1 previous injury to the same shoulder.

Postural analysis

Posture was assessed standing (anteriorly, laterally and posteriorly). Cricketers were assessed wearing shorts. Observations were written in detail in a standardised tabular format. The cricketer's posture was classified as normal, lordotic, lordotic-kyphotic, flat-back or sway back as defined by Kendall *et al.*[12] The presence of scoliosis, with the direction of concavity/convexity, was recorded. Resting scapular position was observed for scapular protraction, elevation, downward rotation or winging of the medial border. Symmetry of iliac crest height, shoulder, pelvic, knee and foot positioning were recorded.

Biomechanical assessment

Assessment of muscular control of the shoulder girdle consisted of observation of scapulohumeral rhythm through glenohumeral abduction and adduction. This included observing incomplete rotation and winging of the scapula during glenohumeral adduction to assess the eccentric function of the scapular stabilisers.[17] Five to 10 repetitions of slow wall push-ups tested the strength of the serratus anterior muscle. The presence or absence of scapular winging or backward rotation was recorded and compared with the opposite side. Glenohumeral flexion, external and internal rotation (90 degree abduction) range of motion were measured in degrees using a goniometre and compared with the opposite side. The hand-behind-back (HBB) test was used to assess for differences in internal rotation ROM between the 2 shoulders. The different levels reached by each thumb were measured. A difference of > 3 cm between sides was considered significant, based on previous clinical experience of athletes of this nature, and to allow for some variance. Measurements from the anterior superior iliac spine to the medial malleolus, and from the umbilicus to the medial malleolus were taken to clinically identify any apparent LLDs.[6,12] The following tests were performed to establish if there was an associated injury to the cervical spine. The ROM of cervical flexion, lateral flexion, rotation, and the quadrant position was observed.[22] The cervical spine, first rib and surrounding soft tissues were palpated to identify increased tissue resistance on one side compared with the other, and a neurological examination was conducted. The upper limb tension test (ULTT1), as described by Butler and Gifford[3] was done to identify altered neurodynamics bilaterally. This testing has been shown to be reliable for detecting the 'onset of pain' during the neural provocation of the upper quadrant (ICC2.1 = 0.98).[4]

Cricketers who either presented to the Academy with a pre-existing shoulder injury, or who injured their shoulder during the Academy underwent a detailed musculo-skeletal examination, in addition to the standard postural and biomechanical assessment, to assist in the accurate diagnosis of the affected structure. This included active, passive and resisted tests, passive accessory joint mobilisation movements, adverse neural tension tests and palpation findings of the shoulder complex and cervical spine. Instability tests included the anterior and posterior drawer test and an inferior glide test, as previously described.[17] Where appropriate, impingement tests included the Hawkins, Neer impingement sign, the empty can test,[2] the scapula retraction test[14] and resisted isometric tests. Furthermore, the pre-Academy assessment findings were analysed in an attempt to identify any pre-injury risk factors, and it was established whether the presenting injury was either new or a recurrence of a previous injury. Players who sustained injuries during the Academy were assessed by 1 of 7 different physiotherapists involved in the injury management of the Academy cricketers from the same physiotherapy practice over the course of 5 years.

For the purposes of this study those players who presented either with a pre-existing shoulder injury, or who injured their shoulder/s over the course of the Academy from 1996 to 2001 were analysed retrospectively.

Results

During the 5-year period under review, 96 male cricketers with a mean age of 20.7 ± 1.9 years attended the Plascon National Cricket Academy. A total of 165 injuries were recorded within this group, of which 71 injuries were pre-existing, and 94 were acute or recurrent injuries sustained during the duration of the Academy. Of the total number of injuries recorded ($N = 165$), 24% were shoulder injuries ($N = 40$). Of these, 72.5% ($N = 29$) were injuries of the dominant arm, whilst 11 were injuries of the non-dominant arm. Eighteen of the 40 shoulder injuries reviewed were recurrent injuries. Some cricketers were recruited to the Academy in subsequent years but none of these sustained shoulder injuries before or during their time at the Academy.

The bowlers and allrounders collectively experienced the most shoulder injuries (80%) (Fig. 1). However, it is interesting that half ($N = 20$) of all shoulder injuries occurred in the field

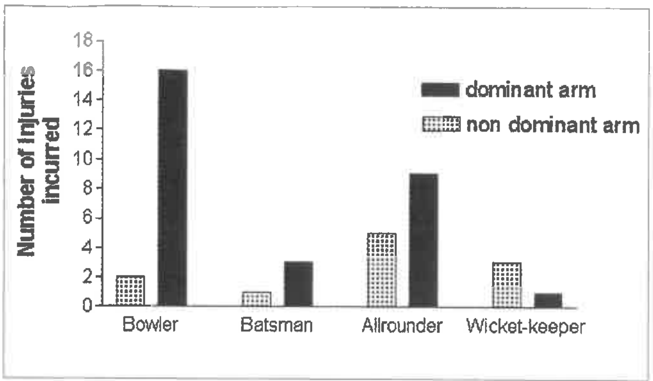

Fig. 1. The spread of shoulder injuries amongst the different specialities.

(diving and throwing), compared with only 6 (15%) whilst bowling (Table I).

TABLE I. The mechanism of injury incurred by the shoulder

Mechanism of injury (*N* = 40)	Number of injuries
Diving	7
Throwing	13
Gradual / overuse	3
Gym	5
Bowling	6
Overstretching	1
Direct blow	2
Batting	1
Other	2

TABLE II. The clinically assessed diagnosis of each cricketer presenting with a shoulder injury

Type of injury incurred (*N* = 40)	Total number of injuries
Impingement syndrome	16
Rotator cuff with instability (secondary impingement)	14
C4 referral	1
Acromio-clavicular joint	2
Biceps tendinosis	2
Postoperative	1
Subacromial bursitis	1
Pectoralis muscle strain	1
Lattisimus dorsi/long head triceps	1
Haematoma (direct blow)	1

The clinical diagnosis of each presenting shoulder injury (*N* = 40) is represented in Table II. This table shows that the majority of injuries were assessed as either a primary (*N* = 16) or secondary (*N* = 14) impingement. Seventeen cricketers (42.5%) had an associated cervical component in addition to their presenting shoulder injury as determined during the assessment.

Postural and biomechanical analysis

The pre-Academy results for weak scapular stabilisers, positive neural tension tests and limited internal rotation ROM (as assessed by the HBB test), are presented for both those cricketers who presented with a pre-existing shoulder injury, a recurrent injury or who re-injured their shoulder during the Academy (Table III). Weak scapular stabilisers (*N* = 15) were a dominant feature in players who presented to the Academy with a pre-existing shoulder injury. Similarly 8 of 19 players who were injured or re-injured during the Academy presented with weak scapular stabilisers at the start of the Academy. Of the 19 players who went on to injure their shoulders only 4 had positive ULTTs at the start of the Academy. The results shown in Table III exclude any positive findings for the unaffected arm. It is interesting that, including the unaffected side, a total of 21 out of 40 players (53%) with a shoulder injury tested positive for the adverse neural tension test. Furthermore, of those 21 cricketers who tested positive with the ULTT test, 15 (71%) had cervical dysfunction, confirmed by other tests described in the methods section.

TABLE III. Results of pre-existing injuries (*N* = 21), injuries or re-injuries during the Academy (*N* = 19) and recurrent shoulder injuries (*N* = 18)

	Affected side		
	Pre -existing injury (*N* = 21)	Injured or re-injured (*N* = 19)	Recurrent (*N* =1 8)
Weak scapular stabilizers	15	8	12
Positive neural tension tests (ULTT1)	9	4	6
Limited shoulder internal rotation (HBB)	13	7	9

Twenty of the 40 players who had a pre-existing, recurrent or acute shoulder injury had a limited HBB test (Table III). Further, 7 players had a limitation in shoulder internal rotation with the unaffected arm. In all 7 cases, the unaffected arm was also that cricketer's dominant arm. Eight of the 20 cricketers with a limited HBB test in the affected arm also had an increase in shoulder external rotation (ER) ROM. There was a normal ER ROM in 9 cricketers, while the remaining 3 cricketers had a loss in ER ROM. In some cases, these dysfunctions were noted bilaterally despite a unilateral injury. Eleven of the 40 cricketers with a pre-existing injury or injury sustained during the academy had bilateral weak scapular stabilisers.

The pre-academy results for weak scapular stabilisers, positive neural tension tests and limited HBB test, are presented in Table III for those cricketers who presented with a history of recurrent or previous injury to the same shoulder (*N* = 18). It is noteworthy that 12 out of 18 had weak scapular stabilisers with testing, and that 9 cricketers had a measurable loss in internal ROM.

There was a large variation in postural types amongst the cricketers, with only 30% of cricketers having a 'normal' posture. Twenty-five of the 40 Academy players who either presented to the Academy with a shoulder injury, or sustained a shoulder injury during the Academy had a scoliosis (Table IV). The majority of these scolioses were in the thoracic spine, convex to the non-dominant side (15/25 = 60%).

TABLE IV. Pre-academy postural findings in those cricketers who presented with either pre-existing injuries or who were injured or re-injured during the Academy

	Pre-existing injuries (N = 21)	Injured or re-injured at Academy (N = 19)
Scoliosis	13 (62%)	12 (63%)
LLD ≥ 1cm	4 (19%)	9 (47.4%)
Normal	5	7
Flat-back	3	1
Sway-back	4	4
Lordosis	7	4
Lordosis / kyphosis	2	4

LLD = Leg length difference.

Forty-seven per cent of cricketers who presented to the Academy with an apparent LLD went on to injure their shoulders during time spent at the Academy (Table IV).

Other postural findings included inverted mid-thoracic spine (spinal segments in extension), abducted (protracted) scapulae at rest overlying a thoracic kyphosis, anteriorly displaced humerii, tight pectoral muscles, a marked forward head posture, decreased glenohumeral flexion, hypomobile segments, generalised hypermobility and ligamentous laxity.

Discussion

The retrospective analysis of the postural and biomechanical assessment conducted prior to the start of the Plascon National Cricket Academy from 1996 to 2001 identified risk factors for potential shoulder injury or re-injury such as player speciality (fast bowler or allrounder), a history of previous injury to the same shoulder, weak scapular stabilisers, scoliosis and a LLD ≥ 1 cm. The high prevalence of existing shoulder injuries in cricketers implies inadequate rest from the aggravating activity, or insufficient, or inappropriate rehabilitation.

The incidence of shoulder injuries amongst cricketers is markedly higher than was reported for shoulder injuries previously.[15,24] This inconsistency may be explained by differing methods in data collection, and the absence of further investigation into injury mechanism or recurrence rates for injuries to the shoulder. Stretch[24] found that the delivery and follow-through in fast bowlers was the primary mechanism of all injuries (25.6%), and that fielding activities (running, diving, catching and throwing) accounted for 14% of the injuries. In the current study, although bowlers and allrounders collectively experienced the most shoulder injuries, it is interesting that most injuries occurred with fielding activities. A possible explanation is that bowlers tend to be rested in the outfield where they are required to both throw with pace, and dive on an outstretched arm to prevent balls from crossing the boundary. As this is a potential injury risk factor, consideration may be given to resting bowlers in different fielding positions.

Injury recurrence

Stretch[24] reports an overall injury recurrence rate of 21.3% in elite cricketers over 2 seasons. In the current study, 45% of shoulder injuries had a history of at least 1 previous injury to the same shoulder, identifying it as an important predictor of future injury. A detailed postural and biomechanical assessment of high-level soccer, Gaelic football and hurling players, supported a history of previous injury as a predictor of future injury.[30] Furthermore, Watson[30] supports the findings of the current study that injury recurrence may be due to insufficient treatment or rehabilitation of the original injury, or the inadequate correction of postural defects and musculoskeletal deficiencies. Sixty-seven per cent of the cricketers who developed recurrent shoulder injuries had clinical signs of weakness of the scapular stabilisers, and 50% had a loss of glenohumeral internal rotation ROM. This is indicative of existing biomechanical dysfunctions that may predispose that cricketer to repetitive re-injury.

Injury nature

A clinical diagnosis of either primary or secondary impingement was made in 75% of injuries in this study. This finding is not surprising, considering the nature of the sport. The ROM found in the typical thrower predisposes the athlete to subtle anterior glenohumeral instability or hypermobility.[8, 11,17] Tightness of the posterior capsule accentuates the anterior translation of the humeral head causing mechanical impingement and a loss of ROM.[8,28] Long training sessions with repetitive forceful bowling or throwing of the ball may lead to fatigue and reduced recruitment of the active stabilisers of the glenohumeral joint (rotator cuff function) or scapulothoracic joint (scapular stabilisers).[9,13] This results in further stretching of the anterior and inferior passive shoulder restraints (inferior glenohumeral ligaments) and superior translation of the humeral head, which results in sub-acromial impingement. This is a collective term for rotator cuff tendonopathy, rotator cuff tear, subacromial bursitis and bicipital tendonosis.[9] Posterior capsule tightness in impingement patients is significantly associated with a loss of internal glenohumeral rotation.[28] Furthermore, it is thought to contribute to altered glenohumeral arthrokinematics.[28] This mechanism is supported by the current study which reported an overall prevalence of posterior capsule tightness, as assessed by the HBB test, of 50%.

The large percentage (42%) of cricketers with shoulder injuries and an associated cervical dysfunction is supported by authors who recognise the inter-relationship between the shoulder girdle and cervical spine in upper quadrant dysfunction, most particularly during repetitive overhead activities.[7,16] This demonstrates the necessity to assess and appropriately treat neighbouring areas to achieve a satisfactory outcome with reduced injury recurrence. The neural tension, as measured by

ULTT1, was not shown to have a strong association with a risk of shoulder injury. However 6 out of 8 players who tested positive for the ULTT at the pre-academy assessment, had coexisting signs of cervical dysfunction with further testing.

Injury risk factors

Weak scapular stabilisers. As 42% of Academy cricketers tested positive for weak scapular stabilisers prior to injuring that shoulder, it is proposed as a risk factor for future injury to the shoulder. Furthermore, the validity of prophylactically managing the dysfunctional shoulder as a means of decreasing injury rates in the elite cricketer is supported despite there being no direct cause-effect relationship between these 2 variables. Weakness of the scapulothoracic musculature could lead to secondary impingement due to disruption of the scapulohumeral rhythm, abnormal positioning and functional scapulothoracic instability.[11] In the current study, the high incidence of weak scapular stabilisers in the cricketing population evaluated supports a reported incidence of scapular instability in 68% of rotator cuff (primary impingement) problems and 100% of glenohumeral instability (secondary impingement) problems.[13]

Hand-behind-back test (HBB). The HBB test assessed the internal rotation ROM. Sixty-two per cent of cricketers who presented to the Academy with a pre-existing injury had limited internal rotation of the affected side, while 37% who went on to injure their shoulders during the Academy and 50% of those with a history of previous injury, had decreased glenohumeral internal rotation ROM. Seven players had decreased internal rotation of the unaffected (dominant) side. This questions the validity of the HBB test as an injury predictor, as it implies that the dominant shoulder does tend to have an internal rotation ROM deficit compared with the non-dominant shoulder. A study to quantify changes in ROM and posterior capsule tightness in patients with dominant or non-dominant shoulder impingement, similarly found that patients with impingement in their non-dominant arm had less loss of internal rotation than patients with impingement in their dominant arm.[28] As a limited HBB test was most prevalent in those players who presented with a pre-existing injury, perhaps ROM limitation only occurs as a result of pain inhibition and pathology, rather than as a risk factor for the pathology itself. This may imply that the HBB test would be less likely to be an injury predictor. However, future studies are needed to assess the value of the HBB test as an injury predictor and to determine the value of the HBB test as an indicator of internal rotation of the shoulder. Furthermore, studies could assess the changes in internal ROM as related to external rotation of the shoulder (a value of total ROM).

Leg length discrepancies (LLDs). A difference of ≥ 1 cm in leg length was considered positive in this study. A poor reliability for this measurement has been demonstrated, with X-rays being the gold standard.[6] However this was beyond the scope of this clinical trial and for this reason a greater difference between left and right leg lengths was chosen.[6] The results from this study suggest that an LLD of ≥ 1 cm may be a risk factor for shoulder injuries in cricketers. As a LLD is associated with a difference in iliac crest height, it is reasonable to assume that a dysfunction of this nature will impact negatively on the upper quadrant, particularly in the active sportsman. For example, a high right iliac crest is associated with a depressed right shoulder, adducted and depressed right scapula and a thoracolumbar scoliosis convex to the left.[12] This is reportedly common in a right-handed dominant person (e.g. fast bowler).[12] As current literature is scant, the relationship between LLDs and shoulder injuries is another worthwhile avenue for future research.

Postural influences. The influence of thoracic spine mobility and curvature (kyphosis and scoliosis), and significant forward head posture (FHP) in subjects with shoulder overuse injuries on shoulder ROM and scapular position have been reported.[1,7,9,13,18] Abnormal thoracic and cervical spine alignment alters the rest position of the scapula, creates shoulder girdle muscle imbalances, joint incongruity and ligamentous laxity, with an associated increased risk of impingement with glenohumeral elevation.[7,11,13,18] The prospective study by Watson[30] indicates that specific postural and musculoskeletal defects, such as muscle imbalances, weakness of muscle groups and joint function are important predictors of future injury in sport. The investigative procedures used in Watson's[30] study supports the clinical evaluation measures used in this research. Further research to validate these clinical tests is justified.

Scoliosis is associated with decreased endplate permeability, which may play a role in disc degeneration.[26] Even minor curves reportedly have wedging of both the vertebra and discs.[26] Scoliosis has been found in up to 80% of athletes with an asymmetric loading on the trunk and shoulders, such as javelin throwers and tennis players.[27] There is no literature pertaining to the prevalence of scoliosis amongst cricketers. The current study assessed scoliosis and found a 63% incidence of scoliosis amongst a cricketing population. This is not surprising due to the asymmetrical nature of cricket, particularly the fast bowlers. The developing elite cricketer is further at risk if playing during an adolescent growth spurt, when the spine is at even greater risk of injury.[27] In the current study, 62% presented with a scoliosis prior to sustaining a shoulder injury. Although no studies were found that specifically related scoliosis to shoulder injuries, the relationship appears to be justified due to the postulated resultant scapular positional changes, concurrent muscle imbalances and changes in gross shoulder movements.[7] This study therefore considers scoliosis to be a strong risk factor for future shoulder injury.

Limitations

Possible limitations include the use of clinical tests that are not validated. However the clinical tests used form the basis of any musculoskeletal screening assessment undertaken by a physiotherapist. The findings provide valid recommendations for future prospective trials, to investigate the validity of the postural and biomechanical assessment tests as predictors of injury. A further limitation includes the number of therapists administering the tests. However, all the physiotherapists received training in the musculoskeletal screening procedures and all tests were standardised. This study was simply a descriptive study and a further prospective study utilising appropriate statistical measures is required to validate these findings.

Conclusion

A history of a previous shoulder injury was highlighted as a significant risk factor for shoulder injuries in elite cricketers. This may be a result of inadequate or inappropriate rehabilitation, or insufficient rest from a long competitive season. Further risk factors include player speciality, weak scapular stabilisers, postural abnormalities, scoliosis and a LLD $\geq$ 1.0 cm. Decreased glenohumeral internal rotation may be a risk factor when related to external rotation ROM and arm dominance.

The majority of injuries were assessed as either primary or secondary impingements, with 42% of all shoulder injuries demonstrating signs of cervical dysfunction. A number of variables in postural classification, which have been associated in the literature with the development of compensatory motion and movement impairment syndromes, were found amongst the cricketers. It is recommended that cricketers undergo a thorough pre-season postural and biomechanical analysis to identify potential injury risk factors. Prophylactic correction of these risk factors may help to minimise the risk and cost of future injury, and to allow the strongest team to be fielded.

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