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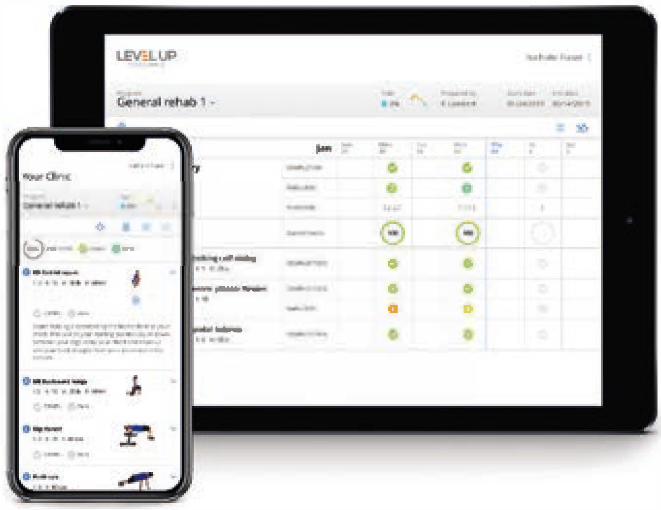

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Editorial

Chain reaction

Hello and welcome to our autumn edition of *In Touch*, your journal designed by, and for, physiotherapists in private practice.

The front cover of this edition illustrates the chain of action and reaction required through the structure of the upper limb to create the momentum for forward motion. In addition, this group of rowers working collaboratively with one another towards their unified goal is the perfect metaphor for how we, as members of Physio First, support and strengthen our position in the race to prove the efficacy and quality of what we do, individually, in our clinical practice. Together we are stronger and more than the sum of our parts.

As you will already know, we can only deliver *In Touch* thanks to the generosity of our authors who volunteer their time and expertise. Their support, awareness of our heritage and future vision, and their preparedness to “buy” into our aims and help us to stay ahead of the knowledge curve means that they are also key members of our team. We are therefore hugely grateful to all our authors for everything they do to support Physio First, and our profession in general.

Our Physio First Quality Assured Practitioner and Quality Assured Clinic schemes demonstrate, with reliable data, that private physiotherapy works. I challenge you to take up the mantle and collect data on which we can stake our present and future reputation as quality clinicians. Your data can also be used to empower your clinical team and educate the public to what a great service we, as Physio First members, offer.

Be part of proving that private physiotherapy works, so that we can be the giants for the next generation of physiotherapists.

TOBIAS BREMER | MSc MCSP | EDITOR

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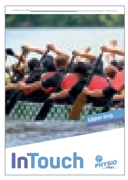

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The kinetic chain approach to shoulder evaluation in athletes

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Shoulder injuries are a common feature in sport and they have reported high recurrence rates which can lead to extended periods of absence from training and competition for the injured athlete. Currently, there are no reported ubiquitous validated instruments that are designed to assess the return to sport requirements of the sporting shoulder. This article, based on the "Athletic Shoulder" course, discusses the methods of assessment and functional rehabilitation that can be applied in the clinical setting.

LEARNING OUTCOMES
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1 Understand how the causes of shoulder injury can differ across different patient groups.
2 Review current practice with regard to the assessment and rehabilitation of shoulder injuries.
3 Improve patient outcomes with treatment programmes that are sport / activity specific to the patient.

Athletes need their shoulders to possess the functional mobility and stability and the force generation capabilities to cope with the demands of their chosen sport. Within some sports, the shoulder has been recorded to move at speeds of between 1,500-10,000 degrees per second (Cavallo & Speer 1998; Kelly & Terry 2001; O'Donnell *et al* 2005) and has been reported at attaining over 16,000 different positions (Andrews & Alexander 1991). Where an individual has already experienced a shoulder injury, there is a four-fold increase in the risk of reoccurrence (Fuller *et al* 2007).

Athlete shoulder injuries therefore are common, yet there are currently no reported reliable instruments designed to assess the requirements of the upper limb in returning the athlete to their sport. The recent development of the Kerlan-Jobe Orthopaedic Clinic (KJOC) shoulder and elbow score has shown to be useful in the assessment of baseball pitchers (Kraeutler *et al* 2013), and several authors have published recommendations on the criteria, e.g. full range of motion (Andrews *et al* 2004; Arroyo *et al* 1997; Wilk *et al* 2002; Kirkley *et al* 1998; Evans 1980; Matheson *et al* 2011), full strength (Andrews *et al* 2004; Wilk *et al* 2002; Putnam 1993; Yamauchi *et al* 2015; Kibler *et al* 2008), and pain free motion (Kirkley *et al* 1998; Matheson *et al* 2011; Yamauchi *et al* 2015; Kibler *et al* 2008; Kibler 1995), that need to be attained when rehabilitating the overhead athletes. While these are proposed, ideal outcome measures for returning to sport, several of these measures have been questioned as to whether they are indicative of functional recovery (Boyle 2016) because, although they are agreed on in principle, they fail to quantify the exact range of movement (ROM) and strength requirements specific to sporting function. Shoulder injury can therefore lead to extended periods of absence from training and competition.

While the exact make-up of the rehabilitation will be specific to the type of injury and the demands of the sport to which the athlete is returning, it has been accepted that the rehabilitation can be divided into distinct, often discrete, stages based on specific entry and exit criteria pertinent to the injured component, the demands of the sport, and the physical characteristics of the athlete. Every patient responds differently to an injury and although the general timeframes for healing have been established (Vleeming *et al* 1995), the reliance on a time-based rehabilitation programme rather than on a goal-driven programme could have detrimental consequences, and even then the decision to return to sport will be based on reliable objective testing.

Return to play criteria

Return to play after shoulder injury should be based on objective measurements (Gumina *et al* 2008) and the process includes evaluation of the athlete's health status, participation risk and extrinsic factors (Lephart 1994).

The problem with criteria such as these is in identifying what is "near normal".

The proposed biomechanical model for hitting and throwing sports is an open-linked system of segments that operates in a proximal-to-distal sequence (Endo *et al* 2016). The purpose of these actions is to convey a high velocity or force via the distal segment. The final velocity of the distal segment is dependent upon the velocity of the proximal segment and the interaction between proximal and distal segments (Evans 1980). With this in mind, further attention should be paid to the position of the athlete at the time when optimal shoulder girdle function is required, and to the requirements of the specific sport (table 1).

Shoulder muscle recruitment patterns and amplitudes, and hence the force produced at the upper limb, is a consequence of the integrated action of the trunk and lower limbs (Yamauchi *et al* 2015; Kibler *et al* 2008). It has been reported that 50% of the force production at the shoulder is obtained via the lower limbs, 30% from the trunk and only 20% locally from the shoulder girdle (Kibler 1995).

Since the entire kinetic chain has a role in optimal function of the shoulder girdle, the distal components and their influence on local function must be taken into consideration. It is essential, therefore, that an attempt is made to identify sub-optimal movement strategies along the length of the whole kinetic chain and address these in the rehabilitation process.
In summarising the primary functional requirements of the kinetic chain, Boyle (2016) indicated whether it is mobility or stability that is necessary at the joint in order for the shoulder girdle to function optimally. The results are an alternating requirement of stability and mobility throughout the kinetic chain (table 2) that need to be evaluated in the context of an overhead athlete.

The scapula acts as a link between the lower limbs and the trunk and the glenohumeral and the upper limb through the fascial connections between gluteus maximus and latissimus dorsi (Vleeming *et al* 1995). This allows for effective force transfer and joint alignment. Establishing a stable base for the scapula is, therefore, essential to minimise stress to the tissues of the shoulder during overhead movements and in facilitating the rotator cuff muscles to maintain the position of the humeral head on the glenoid. The scapula position will be influenced by the architecture and geometry of the thoracic spine (Kebaetse *et al* 1999; Gumina *et al* 2008; Kalra 2010) which can, in turn, be influenced by the function of the lumbar spine, pelvis and lower limbs (Endo *et al* 2016).

A useful screening tool to evaluate the lumbo-pelvic area and lower limb is the Qualitative Analysis of Single Leg Loading System (QASLS), which was produced in a clinical commentary of a task-based rehabilitation programme for elite athletes following Anterior Cruciate Ligament (ACL) repair (Herrington *et al* 2013). It involves dichotomous scoring of the movement strategy occurring in individual body regions of the arm, trunk pelvis, thigh, knee and foot. Scoring is defined as zero for an appropriate strategy and one for inappropriate movements. The best overall score is 0 and the worst 10 (table 3).

Thoracic spine

A reliable measurement of thoracolumbar rotation has been shown to be difficult (Fujimori *et al* 2012; Burkhart *et al* 2003). Crosbie *et al* (2008) reported that the ratio of upper to lower thoracic extension during bilateral arm elevation (figure 1) was 1:3, and that with unilateral arm elevation ipsilateral thoracic rotation occurs, hence the clinical assessment of the spine needs to be incorporated into management. Non-invasive techniques studies with a hand-held goniometry or bubble inclinometry have reported good intra tester (Whatman *et al* 2012; Paterno *et al* 1996). These methods have also set out to measure thoracolumbar rotation as opposed to aiming to measure mainly thoracic rotation.

Johnson *et al* (2012) evaluated, and found reliable, the four-point lumbar locked position for assessment of thoracic spine rotation (figure 2), whereby the subject kneels and sits back on their heels as axial rotation is measured although, as stated by Bucke *et al* (2017), since the thoracic spine is not “locked” a more appropriate name for this test would be the *heel sit position*.

As for extension, the combined elevation test (CET) as shown in figure 1, is a musculoskeletal screening procedure

CONTEXT

WHAT ARE THE FUNCTIONAL REQUIREMENTS OF THE SHOULDER?	
Distal body contact point	• Foot (standing) • Hip (sitting) • Trunk (lying)
Shoulder functional movement	• Above the shoulder • In line with the shoulder
	• Below the shoulder • Unilateral arm action
	• Bilateral arm action
Trunk rotation	• Not required • Symmetrical rotation required
	• Asymmetrical rotation required
Arm action	• Single arm • Double arm
Strength characteristics	• High force
	• High rate of force development (RFD)
	• High endurance capacity
	• High speed

TABLE 1: The context criteria for sporting shoulder function

JOINT	PRIMARY FUNCTIONAL REQUIREMENT
First Metatarsophalangeal joint	Mobility
Mid Tarsal joint	Stability
Ankle	Mobility
Knee	Stability
Hip	Mobility
Lumbar spine	Stability
Thoracic spine	Mobility
Scapula	Stability
Glenohumeral	Mobility

TABLE 2: Primary joint requirements for optimal shoulder function

"IT IS ESSENTIAL TO ESTABLISH A STABLE BASE FOR THE SCAPULA"

	CORRECTIVE STRATEGY	SCORE	
QASLS task	Single leg squat Single leg step down Single leg hop for distance	LEFT	RIGHT
Arm strategy	Excessive arm movement to balance		
Trunk alignment	Leaning in any direction		
Pelvic plane	Loss of horizontal plane Excessive tilt or rotation		
Thigh motion	Weight-bearing thigh moves into hip adduction Non-weight-bearing thigh not held in neutral		
Knee position	Patella pointing towards second / third toes (noticeable valgus) Patella pointing medial to great toe (significant valgus)		
Steady stance	Touches down with non-weight-bearing foot Stance leg wobbles noticeably		

TABLE 3: Qualitative scoring for QASLS

initially established by Blanch (2004) that involves the co-ordinated movements of thoracic extension, glenohumeral joint flexion, scapula retraction and upward rotation (Dennis *et al* 2008). It has been reported as an effective screening tool, measuring upper limb mobility into shoulder flexion and scapula retraction in both sexes (Allen *et al* 2016).

Hip range of movement

Weakness or limited ROM at the hip joint has been shown to produce compensatory adaptations of other segments within the kinetic chain (Sciascia & Cromwell 2012). Several authors have reported a relationship between passive hip external rotation in the stance leg of throwers, and scapular upward rotation and posterior tilt (Kibler *et al* 2006, 2013; Oliver & Weimar 2014), hence the necessity to assess hip range of motion with the hip in an extended position (figure 3) in a standing or lying athlete, but also at some degree of hip flexion which replicates the operating functional position of the hip.

Lumbo-pelvic control

Frontal plane control of the pelvis is controlled by a balance between the lateral stability mechanism of the hip and pelvis, and the forces of the body mass medial to the centre of rotation of the femoral head within the acetabulum (Plisky *et al* 2009; Fujimori *et al* 2012). The gluteal muscles, assisted by the iliotibial band (ITB) are the contributing forces to lateral stability in single leg stance (Fujimori *et al* 2012) and are considered to be part of the components of "core stability". The muscles of the pelvis and trunk maintain control of the spine and pelvis while enabling force transfer from proximal to distal segments during functional activities (Endo *et al* 2016).

DiMattia *et al* (2010) assessed the single leg squat visually, rating the degree of adduction angle of the hip and evaluating the relationship between isometric hip abduction strength, and femoral adduction angles. This was recorded during the Trendelenburg test, or as part of a single leg squat task. Poor correlation between hip abductor muscle strength, and both static and dynamic adduction angles was reported which lead the authors to conclude that the diagnostic utility in the assessment of hip abductor strength was limited, and so these functional tests should not be employed. A more functional assessment of hip abduction strength is by measurement with the athlete lying on their side (figure 4) while a pressure biofeedback unit is placed at the waist to monitor pelvic control while generating hip abduction (Lephart 1994).

In order to analyse the dynamic contribution of the lower limbs to upper body sporting function, the single leg counter movement jump (figure 5) has been reported in many sports as being reliable in the assessment of power development (Evans 1980), and single leg reactive strength being assessed by three hop movement (figure 6) for distance (Putnam 1993).

Trunk stability and control is required in the prevention of athletic injury, and

FIGURE 1: Thoracic extension combined elevation test. Start position: prone arms outstretched. Method: raise both arms as high as possible away from support without flexing elbow. Measure perpendicular distance (cm) from the base of the metacarpal of the thumb to the support

FIGURE 2: Thoracic rotation locked lumbar rotation. Start position: four-point kneeling. Method: an inclinometer positioned between the scapular at T1-T2 level. The athlete is instructed to place one hand on the posterior aspect of the neck and rotate the thoracic spine away from the examiner

FIGURE 3: Hip internal / external. Starting position: supine in a modified Thomas test position. Method: goniometer vertically aligned along the shaft of the tibia. Measure the passive internal and external rotation of the hip range

in optimising performance (Gercek *et al* 2008). The authors described the term “core stability” as the ability to control trunk position and motion for the purpose of optimal production, transfer, and control of forces to and from the terminal segments during functional activities. It has been proposed that a reduced core function is a contributing factor to shoulder injuries in overhead athletes (Gercek *et al* 2008; Heneghan *et al* 2009) as the pelvis and torso contribute as much as 50% of the total force for the kinetics of throwing (Lu *et al* 1997; Oliver & Keeley 2010). Hence assessment of the various components of trunk and lumbo-pelvic muscle recruitment is required.

Trunk performance

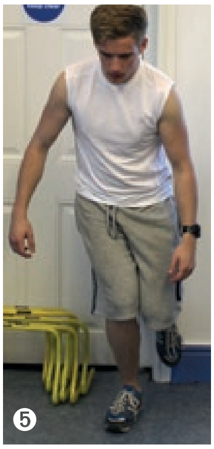
POWER

The muscles of the core have been shown to play a vital role in the process of transferring energy from the trunk to the limbs (Tse *et al* 2005). Core power can be tested by the front abdominal power throw and side abdominal power throw (Cowley & Swensen 2008), using a 2kg medicine ball (figures 7 and 8).

ENDURANCE AND STRENGTH

Trunk endurance can be measured by the extensor endurance test (figure 9) (Biering-Sorensen 1984), the lateral endurance test) (McGill *et al* 2003), the flexor endurance test (figure 10) (McGill *et al* 1999), and the flexion-rotation trunk test) (Brotons-Gil *et al* 2013). Strength is assessed via the double leg lowering test (figure 11) (Cutter & Kevorkian 1999).

FIGURE 4: Hip abduction strength on stable pelvis. Starting position: side lying with pressure bio-feedback monitor located under waist. Method: isometric leg abduction tested



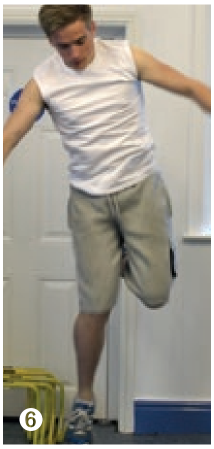


FIGURE 5: Single leg power involving single leg counter movement jump. Starting position: one leg standing. Method: subject flexes at the knee and hip and then immediately extends the knee and hip again to jump vertically. Jump height is recorded

FIGURE 6: Single leg reactive. Starting position: one leg stance on starting line. Method: subject performs three consecutive maximal forward hops on the same limb. Arm swing is allowed. Distance hopped from the starting line to the point where the heel strikes the ground on completion of the third hop is recorded

Another consideration is the assessment of dynamic postural control which incorporates proprioception. Although these measures of dynamic postural stability do not exactly replicate sport participation, they more accurately imitate the demands of physical activity than assessments of postural stability. It has been proposed that proprioception is not only local and joint-specific, controlled by a central process mediated by local receptors (Herrington *et al* 2013), but also a global body-wide process, suggesting that proprioceptive deficits in one area of the body may influence another area (Han *et al* 2013).

The Star Excursion Balance Test (Plisky *et al* 2009) involves strength, flexibility, and proprioception (figure 12). It is a measure of dynamic balance that is a series of single leg squats using the non-stance limb to reach maximally to touch a point along designated intersecting lines on the ground. The normalised value is calculated to present reach distance as a percentage of limb length.

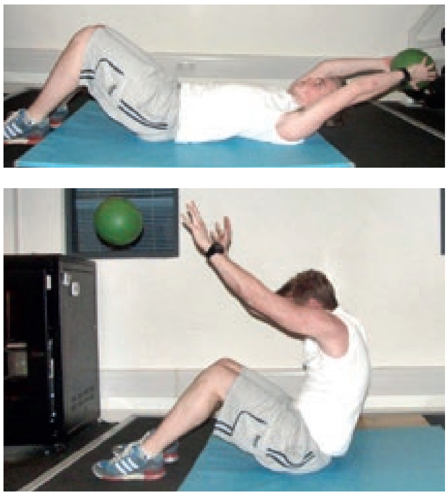


FIGURE 7: Trunk rate of force development – front abdominal power test. Starting position: crook lying with arms overhead holding a 2kg medicine ball. Method: subject performs a sit up while simultaneously using the arms as a lever to project the ball. Feet and buttocks remain in contact with the floor. The medicine ball is released when the hands are over the knees. The landing distance of the ball is recorded

About the author

Ian has been a physiotherapist for more than 20 years, during which time he has worked with various English rugby union teams, including six years working as physiotherapist to the England ‘A’ squad. Currently Ian is Lead Physiotherapist and Technical Lead for the North West for the English Institute of Sport, Clinical Director of Back in Action Rehabilitation in Wakefield, West Yorkshire, Associate Lecturer at Salford University, and a member of the EdCom for EUSSER. He has just concluded his PhD covering the issue of shoulder injuries in professional rugby players and has published several articles in peer reviewed journals on the subject of musculoskeletal injury management, as well as contributing to chapters to several books on sports injury management. Ian worked as part of the HQ medical team for Team England at the 2010 and 2014 Commonwealth Games and was a member of the Team GB HQ medical team at the 2012 and 2016 Olympic Games. Most of Ian’s spare time is spent trying to learn to play golf, supporting Barnsley FC and enjoying some quality time with his wife.

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FIGURE 8: Side abdominal power test. Starting position: seated with knees bent at 90° angle and feet at shoulder width apart, the subject holds a 2kg medicine ball with arms outstretched to the front. Method: maintaining a straight back the subject lowers towards the floor until the hip is at an angle of 45°. The subject then slowly rotates the torso by 90° left / right and, using the arms as a lever, projects the medicine ball. Feet and buttocks should remain in contact with the floor. The ball is released over the contralateral knee and the landing distance of the ball is recorded

FIGURE 9: Extensor endurance test. Starting position: subject is prone with upper edge of the iliac crests aligned with the edge of the plinth. Lower body is fixed to the table with a strap around the pelvis. Initially, the subject's elbows are supported. Method: the elbow support is removed and the subject instructed to fold their arms over their chest. The length of time that the subject can maintain a horizonal position is measured

FIGURE 10: Flexor endurance test. Starting position: the subject adopts a supported sitting position at an angle of 60° with both knees and hips flexed at 90°, the arms folded across the chest and toes placed under a strap. Method: the support is removed and the subject instructed to maintain the position while it is timed

FIGURE 11: Double leg lowering to test trunk muscle strength. Starting position: subject in crook lying with pelvis in neutral and legs passively lifted to 90° hip flexion. Method: a pressure bio-feedback unit, inflated to 40mmHg is placed in the middle of the lumbar lordosis. The subject lowers the legs towards the floor. The range at which the 40mmHg cannot be maintained is recorded

FIGURE 12: Single leg stability star excursion balance test. Starting position: single leg stance in the centre of a star. Method: the non-supporting leg is maximally reached along a set of multi-directional lines (the star) without the subject losing balance. The distance of reach in each direction is recorded

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Rehabilitation of the sporting elbow

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Participation in sport has risen sharply over recent decades and elbow injuries in sport are common. They can be caused by large forces encountered during sporting activities or by direct trauma. Rehabilitation following injury / surgery is vital to restore normal athletic function and to return the individual to sport as quickly and safely as possible. Rehabilitation needs to follow a phased approach in order to ensure healing tissues are protected. The aims are to restore full motion with strength and neuromuscular control. To gain optimal results the programme needs to be tailored specifically to the individual and their sport and focus not only on the upper limb, but on the whole kinetic chain.

LEARNING OUTCOMES
TO SUPPORT PHYSIO FIRST QAP

1. Identify commonly encountered pathology seen in the sporting elbow.
2. Be aware of current evidence regarding the rehabilitation of the elbow.
3. Be aware of the physical criterial needed for the progression of rehabilitation.
4. Understand the need for sport specific programmes to meet the rehabilitation goals of the individual athlete.

Introduction

While the elbow may suffer an acute injury such as dislocation or fracture following a fall, or as a result of participation in a contact sport, the most common mechanism of sports-related elbow injury is associated with repetitive overhead activity. Up to 30% of participants engaged in activities such as throwing, bowling, tennis, swimming and volleyball complain of elbow problems (Conte *et al* 2001; Posner *et al* 2011; Priest 1976; Priest *et al* 1974). The most common athletic injuries include lateral and medial tendinopathies, ulnar collateral ligament injury due to repetitive throwing, and valgus extension overload (VEO).

In the case of VEO, this describes a specific, unique pattern of injuries to the elbow involving a number of forces that act on the elbow during throwing. These include tensile stress along the medial compartment, compressive forces laterally and shear stress seen posteriorly (Wilson *et al* 1983). The forces generated often exceed the tensile strength of primary restraints of the elbow, such as the ulnar collateral ligament, predisposing the joint to injury (Cain *et al* 2003; Dillman *et al* 1991).

Other common sporting injuries to the elbow are described in table 1. It should be noted that the patterns of injuries seen in adolescents will differ from those seen in adults (Cain *et al* 2003).

Physical adaptations to overhead activities

In an athlete competing in overhead sporting activities, the upper limb will develop marked physical adaptations to compensate for the physical forces placed on the structures. These adaptations can be seen in the throwing limb, compared to the contralateral upper limb, and can include range of movement (ROM), ligamentous laxity and muscular compensation, which means that comparisons between the left and right sides of an athlete may not be adequate

CONDITION	CAUSE/DEFINITION
Ulnar collateral ligament tear	Injury on the inner side of the elbow
Ulnar neuritis	Inflammation of the ulnar nerve resulting in numbness or weakness in the hand
Flexor pronator sprain, tear or tendinopathy	Causes include chronic repetitive concentric or eccentric loading of the wrist flexors and pronator teres
Medial epicondyle apophysitis or avulsion	Inflammation of the growth plate on the inner side of the elbow
Lateral epicondylar tendinopathy	Tennis elbow; overuse of the extensor muscles of the forearm
Olecranon osteophytes	Bone spurs
Olecranon stress fractures	Unusual, but can be seen in athletes competing in upper-limb dominant sports
Osteochondritis dissecans	Joint disorder in which cracks form in the articular cartilage resulting in pain and swelling
Loose bodies	Usually form as a result of another problem in the elbow such as osteoarthritis, or a fracture

TABLE 1: Differential diagnosis for elbow pain

> "IMMEDIATE ELBOW MOBILISATION, EVEN POST DISLOCATION RESULTS IN LESS LOSS OF MOTION"

when restoring them to their pre-injury baseline (Crotin & Ramsey 2012; Ellenbecker *et al* 2012; Wilk *et al* 2012). This highlights the importance of pre-season screening of athletes to establish their normative ranges.

A body of evidence shows the presence of medial elbow laxity, significant elbow flexion contractures, and a significant decrease in wrist flexibility in the dominant arm of overhead athletes (Wright *et al* 2006; Ellenbecker *et al* 1998; Shanley *et al* 2011). In tennis players, baseball pitchers and javelin throwers, the dominant arm also shows an increased strength profile in the shoulder internal rotators, elbow, wrist and forearm muscles, and grip strength (Ellenbecker 1991; Ellenbecker & Roetert 2003; Ellenbecker *et al* 2006; Kovacs & Ellenbecker 2011; Laudner *et al* 2012; Wilk *et al* 1993).

However, it should be noted that muscle group strength ratios are sport-specific. For example, in some overhead activities such as volleyball and tennis, high elbow extensor to flexor ratios are seen (Ellenbecker & Roetert 2003), whereas in activities such as judo, there is an almost equal ratio of elbow extensors to flexors (Ruivo *et al* 2012). This should be borne in mind when designing individual rehabilitation programmes.

General rehabilitation

The aim of rehabilitation is to expose healing tissues to appropriate stress and avoid the adverse changes to tissue biomechanics and morphology seen after prolonged immobilisation. According to Wilk *et al* (2012), rehabilitation following elbow injury or surgery follows a sequential, well defined approach, where phases overlap to ensure the athlete returns to their previous functional level as quickly and safely as possible. This approach is based on best current available evidence, adapted to each individual and their respective sport.

Phase 1: acute

This is the immediate motion phase, where the goals are to reduce the deleterious effects of immobilisation, re-establish motion, decrease pain, decrease inflammation and retard muscle atrophy (Wilk *et al* 2004, 2012).

Movement is initiated as soon as it is safely possible, as progressive mechanical loading is more likely to restore morphological characteristics of tissues, such as capsuloligamentous, osteochondral and muscular structures. Animal models have been used in evidence to support the theory that loading upregulates genetic expression for key proteins associated with tissue healing (Bring *et al* 2009; Eliasson *et al* 2009; Martinez *et al* 2007). Clinical studies have also demonstrated that immediate elbow mobilisation, even post-dislocation, results in less loss of motion with no apparent increase in instability (Iordens *et al* 2017; Ross *et al* 1999). The safe arc of motion is dictated by healing constraints of the soft tissues, as well as the specific pathology or surgery, with end range extension being the position. This is often limited to 30 degrees off full extension for the first four weeks post instability in order to reduce the risk of re-dislocation.

Mobilisation exercises in this protective range are performed frequently throughout the day, as defined by the surgery / injury involved. The exercises need to include all planes of movement of the elbow, forearm and wrist, with a bias towards active mobilisation as muscular activation stabilises the elbow, when compared to passive mobilisation alone (Armstrong *et al* 2000; Alolabi 2012). As the elbow joint is especially prone to flexion contractures, the

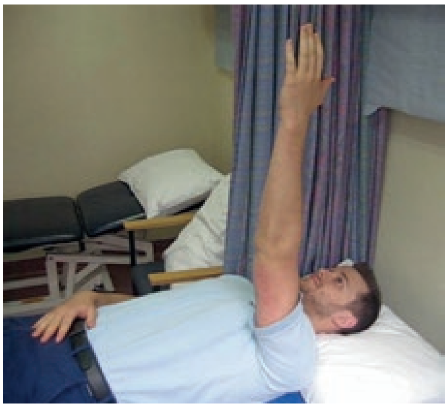

FIGURE 1: The overhead position exercise, aimed at establishing elbow joint extension

primary objective is to establish full pre-injury extension as early as possible.

The overhead position (figure 1), as described by Wolff & Hotchkiss (2006) is the optimal mobilisation position to achieve this goal.

This overhead position has also been demonstrated to maximise elbow stability by minimising ulno-humeral distraction (Alolabi 2012; Lee *et al* 2013). Distraction is most marked with the arm hanging dependent by the side, especially when wearing a cast or hinged elbow brace (Lee *et al* 2013; Manocha *et al* 2016), possibly as a result of the weight of the cast. Exercises involving the arm hanging position should, therefore, be avoided. We do not use hinge braces in elbow rehabilitation because they add no additional benefit to the healing tissue and they have been shown in some studies to increase stress upon ligamentous tissue. Our patients are, therefore, placed in collar and cuff slings, and given advice regarding the safe ROM for exercise.

The overhead position also has the added benefits of minimising biceps electromyography (EMG) activity, which is often seen in the painful, stiff elbow (Page *et al* 2003), while enhancing triceps activity, thereby maximising elbow extension range. While the overhead position is suitable for the majority of individuals with elbow pathology that is being conservatively managed, it is only applicable to immediate post-operative patients where a triceps sparing surgical approach has been taken.

Initially, active assisted flexion / extension, and pro and supination in flexion is performed with the contralateral upper limb providing support where needed. The forearm position during this exercise is dependent on any capsule-ligamentous structures that need protecting. With lateral compartment lesions, the forearm is placed in pronation whereby passive tension in the common extensor origin contributes to lateral stability, whereas supination is the optimal position for medial compartment lesions (Armstrong *et al* 2000). As soon as comfort allows, the exercises are progressed to active movements without assistance.

Care should also be taken during everyday activities to protect healing structures. With lateral ligament injuries, varus stresses such as shoulder abduction with elbow extension should be avoided initially, and with medial ligament injuries, positions of combined shoulder abduction and external rotation are contraindicated because of the increased valgus stresses placed upon the elbow.

It is of great importance that any exercise or alternative techniques used in this stage produce minimal pain as neuropeptides, such as Substance P involved in pain transmission, can be associated with increased myofibroblastic activity (Monument *et al* 2013). This is seen in individuals with contracted elbow capsules, a complication commonly witnessed following elbow trauma or surgery. Supplemental manual therapy in the form of mobilisations with movement (MWM) may also be used with great effect in modulating pain and increasing ROM in the early phase (figure 2).

One possible explanation for the beneficial effect of MWM is that the elbow is poorly innervated in terms of

FIGURE 2: Mobilisation with movement to modulate pain and increase range of movement

articular proprioceptors, and so gains most of its proprioceptive feedback from cutaneous receptors or muscle spindles (Collins *et al* 2005; Fuentes & Bastian 2009). Cutaneous stimulation via a hands-on approach or the use of a simple compression tubular bandage during exercises may therefore help improve proprioceptive input in the injured elbow. In elbow tendinopathy applying MWM can have a demonstrable effect on decreasing pain on symptomatic activities, e.g. grip (Bisset *et al* 2011).

During the immediate motion phase, focus is also placed on voluntary activation of muscles and in reducing muscular atrophy. Isometric exercises of the major muscle groups in the elbow, forearm and wrist are performed. This has been shown to place no additional strain on healing ligamentous grafts (Bernas *et al* 2009). Contractions are performed at the common flexor pronator and the common extensor groups, which are secondary stabilisers of the medial and lateral compartments, respectively (O'Driscoll *et al* 2000). Also, the dynamic stabilisers, producing compression at the elbow, including triceps, biceps and anconeus, are targeted (O'Driscoll *et al* 2000). From both EMG and anatomical studies anconeus appears to be a lateral elbow stabiliser, especially in the lateral ligament deficient elbow, co-opting the ulna to the humerus and reducing postero-lateral rotatory displacement (Badre *et al* 2019; Basmajian & Griffin 1972; Bergin *et al* 2013; Molinier *et al* 2011). Isometric elbow extension activities can facilitate the anconeus, even when the elbow is immobilised in a plaster cast or splint.

Isometric contractions may also have the additional benefit of reducing pain via a generalised, centrally induced pain inhibitory response. The magnitude of this effect increases with contractions of longer durations, of moderate or above intensity (40-50% MVC) and is not constrained to the exercising limb (Koltyn & Umeda 2007; Kosek & Ekholm 1995; Kosek & Lundberg 2003; Lannersten & Kosek 2010; Misra *et al* 2014; Staud *et al* 2005).

One consideration for this stage is if the treatment is conducted post-surgery, what was the original condition of the muscle, and which surgical approach was used. This information is necessary in order to guide early resistance work (Ellenbecker *et al* 2009). For example, a lateral incision with reflection of the common extensor origin would delay implementation of resistance exercises for the wrist and finger extensors. It is vital not only to concentrate on the upper limb, but also on the whole kinetic chain at this stage in rehabilitation, the kinetic chain being a specific sequence of movement which allows efficient accomplishment of a task. Injuries or adaptations in remote areas of the chain can cause problems not only locally, but also distally, as joints such as the elbow compensate for lack of force production and energy delivery through more proximal links (Wilk *et al* 2004; Hannan *et al* 2014).

Kibler and Chandler (1995) calculated that a 20% reduction in kinetic energy delivered from the hip and trunk to the upper limb, requires a 34% increase in rotational velocity of the arm, to impart the same amount of force to the hand.

"CUTANEOUS STIMULATION VIA A HANDS-ON APPROACH MAY HELP IMPROVE PROPRIOCEPTIVE INPUT IN THE INJURED ELBOW"

Hannan *et al* (2014) demonstrated a link between lower limb balance deficits in throwers with medial elbow ligament injuries compared with healthy controls. These balance deficits disappear following a three-month throwers rehab programme that includes the trunk and the lower limb. Therefore, in this early stage while the elbow is recovering, leg and trunk exercises involving sport-specific activation patterns can be initiated so that the base of the kinetic chain is ready for the intermediate phase of rehabilitation.

Phase 2: intermediate

This stage of the rehabilitation programme is commenced when the patient has achieved a return to 90% pre-injury range with minimal pain and tenderness, and good strength of elbow and forearm musculature (Wilk *et al* 2012), usually at four to six-weeks post injury / surgery.

Elbow extension and forearm pronation is of particular importance for effective performance in throwing sports (Wilk *et al* 2012). Local strengthening exercises are progressed to isotonic contractions, beginning with concentric work and then on to eccentric movements with emphasis placed on the secondary stabilisers. With medial compartment symptoms, emphasis should be placed on the flexor pronator mass, especially flexor carpi ulnaris which in anatomical and EMG studies have been shown to contribute to valgus stability by reducing forces placed on ulnar collateral ligament during throwing (Lin Fang *et al* 2007; Otoshi *et al* 2014; Park & Ahmad 2004; Perry & Jobe 1995). With lateral compartment instability, emphasis should be placed on the wrist extensors and anconeus.

The kinetic chain can also be incorporated into exercise programmes, with resisted overhead elbow extension activity, incorporating the lower limbs (figure 3).

With tendinopathy, the key goal is improving the capacity of the tendon and muscle to manage load. Strengthening options, such as isometric and isotonic exercises, as well as heavy slow resistance work, all share a common goal of

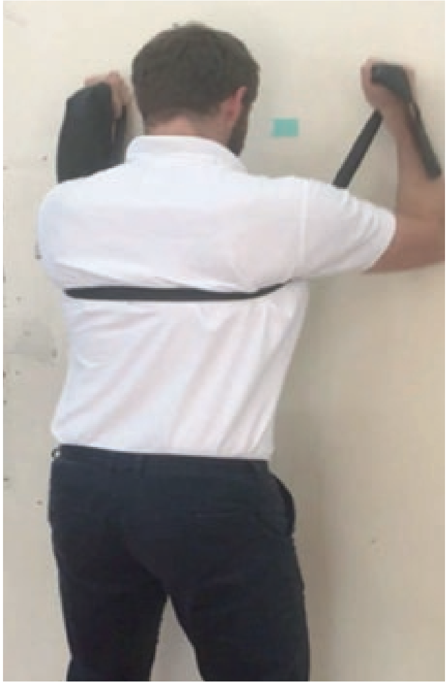

FIGURE 3: Resisted overhead elbow extension exercises

gradually increasing load, while carefully monitoring pain (Coombes *et al* 2015). Isometric strengthening exercises, i.e. holding the wrist in a neutral position for prolonged periods, while pushing / pulling, may prove especially beneficial as they mimic the functional activation of the short wrist extensors.

A progressive loading approach for tendinopathy has been supported by clinical trials with long-term benefits seen, compared with pharmacological and electrotherapy interventions (Bisset *et al* 2006; Pienimaki *et al* 1996; Stasinopoulos *et al* 2005; Svernlöv & Adolfsson 2001).There is also gold standard evidence that, when compared with a 'wait and see' approach or physiotherapy treatment, steroid injection should be avoided in the management of lateral elbow tendinopathy as it predisposes an individual to increased risk of recurrence (Coombes *et al* 2013; Bisset *et al* 2014). The evidence for counterforce bracing is limited, but research indicates that it should only be worn during pain-provoking activities and only used for individuals where it demonstrably reduces pain or improves grip (Bisset *et al* 2014; Ng 2005).

Shoulder flexibility and shoulder and scapula strength are also addressed at the intermediate stage. Loss of total shoulder rotational range has been shown to place strain on medial elbow structures during throwing (Dines *et al* 2009). As previously mentioned, care should be taken with stretches at extremes of glenohumeral external rotation to avoid stress to the medial ligament complex. It must be considered that range loss may be a problem of control rather than of capsular origin, therefore, for this group stretching may not be effective and the problem should be addressed by performing exercises to promote control through range. It is essential that the individual is carefully assessed to ensure that any deficit, whether ROM or active control of the upper quadrant, is managed appropriately. With regard to addressing shoulder and scapula strength (Ellenbecker *et al* 2012; Wilk *et al* 2012) this stage can incorporate the throwers 10-strengthening programme that has been designed from EMG evidence to illicit the muscular activity most needed to provide upper limb dynamic stability. This programme has demonstrated an increase in throwing velocity after six weeks (Escamilla *et al* 2012; Reinold *et al* 2004, 2007). Studies have shown that individuals with elbow tendinopathy demonstrate, possibly owing to pain inhibition and disuse, global weakness affecting all major shoulder groups in the affected upper limb, so attention should be paid to global upper limb strengthening (Alizadehkhaiyat *et al* 2007).

Phase 3: late-stage rehabilitation

The ultimate aim of late-stage rehabilitation is to prepare the individual for a return to sport with confidence and with as minimal risk of injury as possible. In order to achieve this, full concentric and eccentric strength, power, endurance and control must be achieved throughout the upper quadrant and kinetic chain.

The physical criteria to progress to this stage include minimal or no pain or tenderness on palpation, near full active ROM, strength that is 70% of the contralateral limb strength, and a functional score based on QuickDASH or similar subjective outcome, that indicates less than 15% impairment (Wilk *et al* 2012). It is essential that the stage of healing is considered specifically for the injured tissue type and that the tissue involved is theoretically considered to have achieved a sufficient degree of repair or stability. It is suggested that, depending on the individual and the particular tissue type, progression to late stage rehabilitation will commence between seven- and 12-weeks post injury or surgery.

Late-stage rehabilitation will continue until the individual successfully returns to sport, which may take up to 12 months following a ligament reconstruction (Ellenbecker *et al* 2009). At three-months post-op, rehabilitation will include short periods of throwing, an exercise programme with a gradual increase in resistance, an increase in muscle work through a wider ROM, and a steady increase in lever length. The programme should gradually become more dynamic, with a reduction in predictability and an increase in weight-bearing exercise and activities. Plyometric exercise and controlled impact work should also commence at this stage.

It is also vital at this stage to address any deficits or ongoing problems in terms of ROM, such as a lack of elbow extension and / or flexion, by returning to the basics of earlier stages of rehabilitation, such as overhead mobilisation exercises to regain elbow range.

As studies show a decrease in neuromuscular control, kinaesthetic detection, strength and throwing accuracy are all associated with muscular fatigue, multiple set exercises aimed at gradually increasing strength, power, and to promote endurance are a key component of this stage (Ellenbecker *et al* 2012).

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OVERHEAD REHABILITATION

The biceps are important stabilisers during the follow-through stage, so elbow flexion exercises are progressed to emphasise eccentric control as this prevents pathological abuttal of the olecranon in the olecranon fossa. In addition, as the triceps are seen to be involved during the acceleration phase of throwing, concentric tricep activity is emphasised through exercises (figure 4) that can be progressed in the supine position from both arms to single arm throw. Load can be increased by substituting a light football or gym ball with a medicine ball.

Resistance exercises should closely simulate the demands of the athlete's specific sport, e.g. throwing or tennis service action. Methods such as the Advanced Throwers Ten Programme incorporate exercise and movement patterns specific to the throwing motion and utilise the principle of co-activation, high level neuromuscular control, dynamic stability, endurance and co-ordination that are vital in the overhead athlete. For swimmers, however, Swiss ball exercises performed in the prone position with the feet off the floor may offer rehabilitation activity more specific to the demands of this particular sport. As previously mentioned, exercises to promote endurance should be emphasised during this phase because performing while fatigued puts the overhead athlete at risk of injury (Carpenter *et al* 1998; Guskiewicz *et al* 1999). Endurance drills using lower weights and higher repetitions have been shown to preferentially load the key muscle groups required in overhead sport.

FIGURE 4: Concentric tricep activity; exercises in a supine position with the use of a gym ball

PLYOMETRIC EXERCISES

Fatigue also adversely affects proprioception, therefore endurance activities are critical in improving co-ordination and joint stability through the use of controlled impact work and plyometric exercises, the latter of which can be a beneficial form of functional exercise for training the elbow, and have been shown to increase throwing and service action speeds, increase elbow extension power and improve measures of proprioception and kinaesthesia. The key concept of plyometric exercises is in the stretch of the musculotendinous unit, immediately followed by shortening, with the stretch-shortening cycle enhancing the ability of the musculotendinous unit to produce maximum force in the shortest time. It has been suggested that, for an athlete to gain maximum benefit, plyometric exercises should be performed in conjunction with other forms of strengthening programmes. Initially, plyometric exercises are performed with both upper limbs, i.e. chest pass, side pass and overhead football throw in the standing or supine position (figure 5).

Patients are then progressed to one-handed throwing in the 90 / 90 position, and specific plyometric drills are introduced for the forearm musculature, including wrist flips, wrist snaps and extension grips.

> "IN LATE-STAGE REHABILITATION IT IS VITAL TO ADDRESS ANY RANGE OF MOVEMENT PROBLEMS BY RETURNING TO THE EARLY STAGE BASICS"

CONTACT SPORT REHABILITATION

For individuals who wish to return to contact sports such as rugby, it is vital to address impact work at this stage. Previous studies have shown that increased muscle activation patterns of the elbow and wrist during forward falls increase the transition of force through the forearm (Burkhart & Andrews 2013). With practice, individuals can select the upper extremity posture, allowing them to minimise the effects of impact. Lo *et al* (2003) showed that practising five to 10 repetitions of forward falls resulted in decreased impact forces in the upper limb during subsequent falls, for the following two months.

Phase 4: return to sport

To progress to this stage the athlete should have attained full ROM with no pain or tenderness, developed good strength, endurance and stability of the upper extremity and scapula, have an outcome score of 0% disability on QuickDASH or its equivalent, and demonstrate knowledge of, and compliance with their individualised home exercise programme.

Traditional exercise programmes cannot reproduce speed or joint forces generated in sport. The only way to mimic these is to practise the sport concerned. Interval training programmes are progressive, sport-specific regimes that have been described for swimming, golf, tennis and throwing sports to gradually expose an athlete to the demands they will experience upon return to sport.

INTERVAL SPORTS PROGRAMME

Prior to the initiation of the interval sports programme (ISP), the athlete's throwing motion and kinetic chain stability should be assessed. A focused warm-up programme, which can be reproduced by the athlete on return to full participation in sport, is implemented prior to every session of the ISP and, at the start of a session, an athlete's strength and flexibility are measured with an expectation that the individual maintains these levels at 90%, following execution of the programme.

FIGURE 5: Plyometric exercise in the standing position

The ISP should progress through four distinct stages: return to sport, basic, advanced, and simulated competition. The amount of time spent at each stage is dictated by the type of injury / surgery the athlete has sustained as well as any symptoms in response to the programme. If, at any stage, the athlete experiences pain with or after activity, a reduction in strength or range of motion, or if they have generalised upper limb soreness lasting more than 24 hours, they should remain at that stage until symptoms resolve.

The throwing interval programme gradually increases the number, intensity and type of throw, which are all progressed gradually to minimise the risk of overload at the elbow. Throwers generally begin with shorter distances at 50% throwing intensity, increasing to 100% over a four to six-week period. However, the athlete must be educated upon the importance of following a structured regime, as previous studies have demonstrated that athletes significantly underestimate the amount of effort they put in, thus predisposing themselves to potential injury. Rehabilitation will continue with frequent monitoring until the individual successfully returns to sport. This is a process that, depending on the type / site of injury and its management, may take anything from up to nine to 12 months to achieve (Ellenbecker *et al* 2009), although throwing for short periods of time should be possible at three-months post-op. Shanley *et al* (2012) recommend frequent communication between the athlete, coaching staff and rehabilitation team to offer support until return to competition, and to reduce the risk of injury.

Injury prevention

The most important tenets of the prevention programme are education, identification of at-risk athletes, full rehabilitation of past or current injuries, and monitoring athletes for the development of warning signs for injury. Athletes with a previous history of tendinopathy should be given a controlled tendon loading programme to be followed throughout the off-season in order to prevent any reduction in the tendon load. On return to pre-season training, the programme should include appropriately spaced and graduated increase in loading of exercises. In the absence of such strategies, an athlete will be predisposed to an active tendinopathy upon resumption of full training and competition activities.

About the author

Val Jones is a Clinical Physiotherapy Specialist working at the Shoulder and Elbow Unit at the Sheffield Teaching Hospital Foundation Trust. She also works in private practice and lectures nationally and internationally about the assessment and rehabilitation of the elbow joint. Val has published in peer reviewed journals and is a previous Allied Health Professional representative on the British Elbow and Shoulder Society Council, as well as being the current UK national delegate for European Society for Shoulder and Elbow Rehabilitation. She has been awarded a prestigious Copeland Fellowship from the British Elbow and Shoulder Society, travelling to Cape Town to discuss rehabilitation of the elbow.

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The role of physiotherapy in non-traumatic hand and wrist conditions

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Non traumatic hand and wrist conditions are common and as with all hand conditions the role of the therapist is intrinsic to positive outcomes for patients. This article aims to provide a summary of the evidence base for non-operative treatments for several of the common conditions encountered in practice, and also how hand therapy can augment surgical treatment to maximise patient outcomes.

LEARNING OUTCOMES
TO SUPPORT PHYSIO FIRST QAP

1. Increase awareness of hand and wrist conditions.
2. Understand the basic principles of the condition.
3. Understand the important role of therapy as first line management of hand conditions.

Carpal tunnel syndrome

Carpal tunnel syndrome (CTS) is one of the most common reasons for patients to present for hand surgical consultation and is the most common peripheral nerve entrapment (de Krom *et al* 1992). Physiotherapy can play a role in both the operative and non-operative treatment of the condition (Huisstede *et al* 2010a).

The condition is caused by compression of the median nerve as it runs through the carpal tunnel, and presents clinically with altered sensation in the thumb, index and middle fingers (figure 1) and, in the later stages, with wasting of the thenar muscles, i.e. those on the fleshy part of the hand at the base of the thumb. Night pain and pins and needles are also a classic feature of CTS (Aroori & Spence 2008), which is usually linked to heavy manual work and repetitive flexion and extension of the wrist.

As a common condition, CTS has been extensively studied and reviewed. It is known that in response to changes in the upper limb position, the median nerve glides relative to the surrounding tissues in both the longitudinal and transverse planes (Coppieters & Butler 2008; Park 2017), and it is thought that it is the impaired normal gliding of the median nerve that plays a role in the pathogenesis of the condition (Hough *et al* 2007; Greening *et al* 1999). This has led to an investigation of techniques aimed at restoring normal gliding. Two trials (Bialosky *et al* 2009; Wolny & Linek 2018) of neurodynamic techniques versus sham techniques have reported positive outcomes. Bialosky *et al* (2009) looked at a three-week course of therapy plus night splinting, and showed an improvement in clinical pain intensity, while Wolny & Linek (2018) used a 10-week course of bi-weekly treatments that showed improvements in symptom severity scores and neurophysiology measurements.

While a recent review highlights that, in the short to medium term, splinting in a

FIGURE 1: Carpal tunnel syndrome: patient displays symptoms of severe wasting of the thenar muscles. The injury to the tip of the finger on the right hand occurred owing to loss of sensation in the fingers

> "ORTHOSIS WITH PHYSIOTHERAPY IS MORE EFFECTIVE THAN ORTHOSIS ALONE FOR THE RELIEF OF BASE OF THUMB OSTEOARTHRITIS"

neutral position and steroid injections are equivalent to surgical decompression of the carpal tunnel, in longer follow-up, i.e. one year or greater, the research shows that surgery, whether open or endoscopic, can benefit the patient (Huisstede *et al* 2010b).

The post-operative management of carpal tunnel release has explored various methods aimed at improving outcome and speeding up return to work. There is no evident benefit shown that cold therapy, laser, splinting and dexterity training are an improvement over standard care. The only intervention supported with evidence is the reduction of the bulky surgical dressing after between 48 and 72 hours, and mobilisation (Huisstede *et al* 2018).

Base of thumb osteoarthritis

This is a common finding on radiography, although not all patients are symptomatic (Marshall *et al* 2011; Woolf & Pfleger 2003). The thumb carpometacarpal (CMC) joint allows for a wide range on movement in flexion, e.g. extension / abduction, adduction, as well as opposition; a composite movement of flexion and pronation. The CMC joint is stabilised by lateral, dorsal and volar or beak ligaments. This latter of the ligament is the most important as it is thought that its failure leads to degenerative changes in the CMC.

Patients with this condition will present with pain that is often aggravated by pinch or power grip. The base of the thumb is often squared off (figure 2), and other examination findings include adduction contracture of the first web space with compensatory hyperextension of the metacarpophalangeal joint (MCPJ). Base of the thumb osteoarthritis (OA) often co-exists with CTS, as described earlier, and the condition known as Trigger Finger (see later).

A variety of treatments, ranging from simple analgesia up to total CMC joint arthroplasty, are available (Joshi 2005; Stamm *et al* 2002; Matullo *et al* 2007). There is good evidence that non-operative measures are effective at reducing the need for surgical intervention. A 2018 meta-analysis of five high-quality random controlled trials (Woolf & Pfleger 2003) showed that unimodal and multimodal therapies gave clinically important improvements in pain with a mean difference (MD) of 3.1 [95% CI 2.5 to 3.8] and 2.9 [95% CI 2.8 to 3.0] on a 0-10 scale. There was also an improvement in hand function with both uni- and multimodal therapies, with a greater affect size with multimodal therapies (MD 6.8 points [95% CI 1.7 to 11.9)] on a 0-100 scale, MD 20.5 (95%CI -0.7 to 41.7) respectively.

A systematic review of 27 published studies by Aebischer *et al* (2016) of non-operative management of base of thumb OA concluded the same; that multimodal therapy including orthosis and physiotherapy was effective in the relief of pain and more effective than orthosis alone. It also highlighted that off-the-shelf neoprene supports were as efficacious as custom-made orthosis.

A more recent prospective study from 15 clinics in the Netherlands looked for factors predictive of failure of non-operative management, and when it should be deemed that non-operative management has failed (Tsehaie *et al* 2019). The protocol included splintage of the thumb with the first CMC in extension and the MCP joint in slight flexion. Patients were given two 25-minute hand therapy sessions per week during the study period. The study indicated that, for change in pain on the Visual Analogue Scale (VAS) after three months, the multivariable regression model explained 34% of the variance in outcome ($p<.001$) with pain intensity during the week prior to the baseline measurement being a significant predictor. There was no receiver operating characteristics (ROC) curve reported to set a cut off on the pain indicator. The authors concluded that intrusive pain in the week leading up to consultation is most predictive of the failure of conservative treatment, and that patients who have failed to show improvement six weeks after the start of the therapy are unlikely to improve thereafter. The study does note, however, that even those patients presenting with severe pain and low function benefited from non-operative management, so concluded that all patients should be offered non-operative treatment in the first instance (Tsehaie *et al* 2019).

FIGURE 2: Base of thumb OA: shows the classic squared-off thumb base and the compensatory thumb metacarpophalangeal hyperextension

Stenosing tenosynovitis

More commonly known as Trigger Finger, stenosing tenosynovitis can affect any of the digits, including the thumb. It is a condition that presents in middle aged women, often in the dominate hand, with the locking of the affected digit in the flexed position which, although initially non-painful, can become painful with progression. The thickening and entrapment of the tendon is usually at the level of the A1 pully, and a nodule may be palpable at the level of the metacarpal head. The condition is associated with other non-traumatic hand and wrist complaints including CTS, de Quervain's tenosynovitis and Dupuytren's contracture. It is also common in diabetics and often refractory to non-operative management in this group (Makkouk *et al* 2008; Nimigan *et al* 2006; Chammas *et al* 1995).

Potential treatments for Trigger Finger include non-steroidal anti-inflammatories, steroid injection and either percutaneous or open A1 pully release (Huisstede *et al* 2014; Lunsford *et al* 2019). Lunsford *et al* (2009) also reviewed six studies on the use of orthotics and exercise programmes for the treatment of Trigger Finger with reported patient satisfaction scores between 43-93%. There is no consensus between the papers on the optimum regime with splints, including the distal interphalangeal joint (DIPJ) or MCPJ and being worn for between three to 12 weeks. The inclusion of a daily exercise regime also varied from between two-hourly mobilisation and no prescribed exercise. Patient satisfaction rates in the studies that reported one-year follow-up were at 81-87%. However, in one study where the splint was worn only at night, the patient satisfaction rate was reported at only 53% (Drijkoningen *et al* 2017). One study suggested a high success rate in a cohort of patients treated with orthotics, with only 13% requiring either surgery or steroid inject during the five-year follow-up period (Valdes 2012), which compares favourably with primary use of steroid injection in the review undertaken by Huisstede *et al* (2010b) whose findings show that there is moderate evidence for the use of steroid injections in Trigger Finger, although the duration of symptom relief in the studies cited is only short-term, i.e. < six months. It is the senior author's preferred practice to offer a corticosteroid injection to patients with Trigger Finger, however, if regular triggering occurs in the middle or ring fingers, then a percutaneous release may be offered. Resistant cases may be considered for open release.

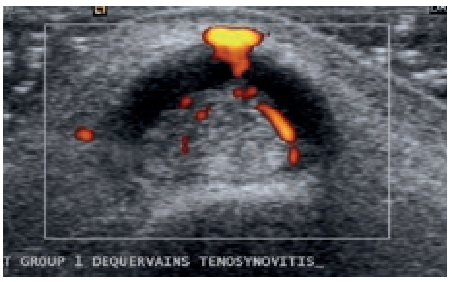

FIGURE 3: Ultrasound scan of de Quervain's tenosynovitis

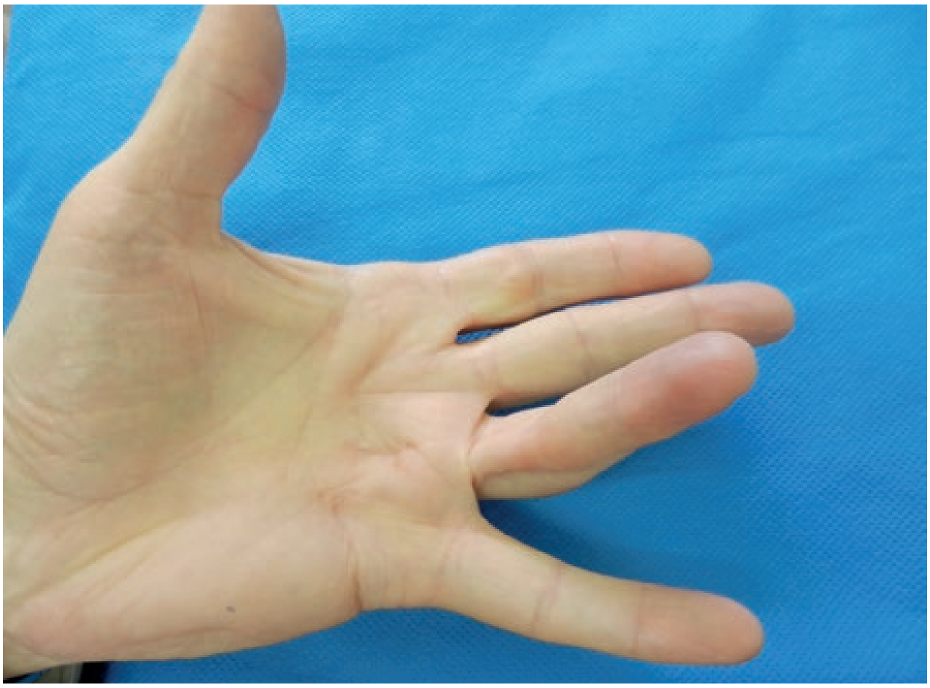

FIGURE 4: Dupuytren's disease: characterised by fixed flexion contracture of one or multiple digits

Dupuytren's contracture

Characterised by a progressive fixed flexion contracture of one or multiple digits (figure 4), Dupuytren's is caused by the proliferation of myofibroblasts that affect the palmar and digital facias (Picardo & Khan 2012). It presents with palpable cords and nodules that can be painful in the active phase. Various non-operative treatments have been investigated, including radiotherapy, topical vitamin A and E application, orthotics, steroid injections and five-fluorouracil treatment. While radiotherapy still remains a treatment option, it is not widely used and is generally only suitable for the mild stage of the disease and not at the point when the contracture becomes functionally impeding (Werker *et al* 2012; Rayan 2008; Badalamente & Hurst 1999). Treatment for patients with functional limitations tends to be surgical, either through percutaneous needle fasciotomy, collagenase injections or formal open excision of the cords (Sweet & Blackmore 2014).

Following National Institute of Clinical Excellence (NICE) approval, the use of collagenase treatment may increase in popularity in the future (NICE 2017). The Cord II trial protocol (Gilpin *et al* 2010) showed that results achieved for MCPJ contracture were better than those for the proximal interphalangeal joint (PIPJ). Skirven *et al* (2013) suggested a different protocol for severe PIPJ contracture (fixed flexion contracture >40 degrees). For the first week patients were splinted continually with the PIPJ in maximal extension and the MCPJ in the position of safety, this was then changed to a daytime only finger-based orthosis for the PIPJ. On day one, exercises commenced to recruit the lateral bands and oblique retinacular ligaments. The

"NONE OF THE STUDIES INTO NIGHT SPLINTING FOR DUPUYTREN'S DISEASE DEMONSTRATE A DIFFERENCE IN RECURRENCE OF FLEXION CONTRACTURE AT THREE MONTHS OR MORE"

patients underwent a weekly follow-up for review and adjustment. At four-weeks post collagenase treatment and manipulation, 22 digits from 21 patients showed an improvement from PIPJ contracture from 56° to 7° (Sweet & Blackmore 2014).

Loss of extension, caused by the attenuation of tissues especially the extensor mechanism in zone 3, is an issue in all forms of intervention (Tonkin & Burke 1985). While it makes sense that extension splinting of these deficits will allow the stretched tissues to shorten and volar subluxed lateral bands to resume a more anatomical position, clinical evidence to support this is lacking. Additionally, although night splints are recommended by European consensus, the guidelines also have limited evidence for use. The issue of night splints fasciectomy or dermo-fasciectomy investigated by three RCTs resulted in only one finding, at the six-week time point in favour of any benefit of splinting, none of the studies demonstrated a difference in the recurrence of flexion contracture in patient reported outcomes at three months or more (Kemler *et al* 2012; Collis *et al* 2013; Jerosch-Herold *et al* 2011).

Swelling is also an issue after Dupuytren's surgery. In their RCT, Hazarika *et al* (1979) compared intermittent compression with continuous compression and found in favour of intermittent compression following fasciotomy.

Osteoarthritis of the metacarpal phalangeal joint and interphalangeal joints

For this common condition (figure 5), the European League Against Rheumatism (EULAR) recommend the local application of heat in the form of paraffin baths, heat packs or ultrasound (Zhang *et al* 2006). This advice is based on expert opinion and research. Dilek *et al* (2013) published the findings of an RCT in which 56 patients were treated with either five-times weekly paraffin baths under the supervision of a therapist, or received no therapy and no treatment other than oral analgesia. In this study the intervention group showed improvement in pain at rest and during activities of daily living.

FIGURE 5: Osteoarthritis in the small joints of the hand

There are a variety of surgical approaches for PIPJ arthroplasty, including volar, direct transverse and dorsal, and these need to be considered when evaluating the post-operative patient. The volar approach has a perceived advantage as, unlike the dorsal approach the extensor mechanism is not violated and, therefore, the requirement for post-operative splinting and limitation of flexion may not be required. From collated outcomes taken from the literature, there also appears to be a slight advantage to the volar approach in terms of range of motion (ROM), but this is unlikely to be functionally significant (Bouacida *et al* 2014).

De Quervain's tenosynovitis

De Quervain's presents with radial sided wrist pain and swelling (Ashe *et al* 2004). It affects the first dorsal compartment containing the extensor pollicis brevis (EPB) and abductor pollicis longus (APL) (Kutsumi *et al* 2005). The underlying pathology is one of thickening of the tendon sheath, however inflammation is not a common feature (Clarke *et al* 1998). de Quervain's is much more common in patients who perform repetitive manual work, and a link has been shown between the magnitude of the repetitive force and the rate at which the condition develops (Bystrom *et al* 1995; Muggleton *et al* 1999).

The mainstay of non-operative treatment for de Quervain's are orthotics and steroid injection.

Lane *et al* (2001) performed a retrospective review of 319 wrists in 300 patients. These patients were stratified into mild, moderate and severe groups. Follow-up intervals ranged from one to six years. Of the group, 19 patients presented with mild symptoms and these were treated with orthotics and non-steroidal anti-inflammatories, resulting in 17 of the 19 being satisfied with the outcome. Those patients with severe symptoms represented the vast majority (249). This cohort were treated with corticosteroid injection, resulting in complete relief for 76% of patients, and only 4% showing no improvement.

It is known that the APL and EPB can run in separate sub-sheaths and that de Quervains is more common in this group (Kulthanan & Chareonwat 2007). This may explain why there is evidence that ultrasound guided injection or injection at multiple sites is more effective than single injection using landmarks (Huisstede *et al* 2010b; Kume *et al* 2012). As with other conditions covered in this article both orthotics and steroid injection have been shown to be of benefit but are more effective when used in combination (Cavaleri *et al* 2016).

There has been a recent trend to treat tendinopathies in the lower limb with high load eccentric exercises. It is questionable whether this approach can be applied to the upper limb where tendons are not eccentrically loaded under physiological conditions and are often contained within fibrous sheaths to conform to anatomy or improve mechanical advantage, rather than having a straight line of pull as found in the Achilles tendon, or the extensor mechanism of the knee. There are also practical considerations with regard to the application of eccentric load to the upper limb. Saying that, some studies have shown some promising results (Fedorczyk 2012) and this is an area in need of further investigation.

It is the senior author's preferred practice to offer a low dose corticosteroid injection in patients with de Quervain's disease. In many cases the fluid injected into the compartment releases the adhesions and provides immediate and complete pain relief from the hydrostatic volume effect rather than the cortisone. Resistant cases may be considered for open release.

"A LINK HAS BEEN SHOWN BETWEEN THE MAGNITUDE OF REPETITIVE FORCE AND THE RATE AT WHICH DE QUERVAIN'S DEVELOPS"

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Shoulder injuries and injury prevention in rugby union

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Shoulder injuries are a significant problem in rugby at all playing levels irrespective of the injury definition. The higher incidence of shoulder injuries is reported at the higher playing level, however there are concerns about the high shoulder injury rates in academy youth players. Acromioclavicular joint sprain and shoulder instability and dislocation are the most common injuries resulting in the greatest days absence, respectively. The tackle has been identified as the most common mechanism of injury. Neuromuscular training programmes are efficacious in preventing the risk of injuries and used in a number of sports, yet all suffer from poor compliance.

LEARNING OUTCOMES
TO SUPPORT PHYSIO FIRST QAP

1 Awareness of the extent of shoulder injuries prevalent in rugby union.
2 Understand the risk factors and mechanisms for shoulder injury.
3 Consider the scope for shoulder injury prevention and the need for implementation research in rugby.

Introduction

Rugby is a popular sport that offers an opportunity to promote physical activity for children and adults as a means of reducing the risk of developing hypokinetic diseases such as obesity, diabetes and heart disease (Blair 2009; Matheson *et al* 2013; Trost *et al* 2014). Sport participation is not without the risk of sustaining an injury which consequently is the leading reason why people discontinue from participating in physical activity (MacKay *et al* 2004). Limiting the risk of injury through effective evidence-based injury prevention strategies may increase the likelihood of benefits associated with physical activity.

To date, emphasis in the rugby research community has largely been on addressing high risk injuries, such as catastrophic injury or those that carry a high injury burden. Injuries to the spinal cord, those that affect the stability of the knee, and concussion have received much of this focus (Cazzola *et al* 2014; Fuller *et al* 2007; Preatoni *et al* 2016). Notably, studies also show that upper limb injuries are a significant problem, accounting for 14% – 28% of all rugby injuries (Usman & McIntosh 2013). Reviewing the current evidence on shoulder injury epidemiology across all playing levels of rugby union is crucial to grasp the magnitude of the problem and to determine the level of risk for players, thereby informing where our future preventative efforts should be focused. These efforts are intended to decrease the risk of injury recurrences, prevent the development of long-term musculoskeletal conditions and encourage a physically active lifestyle across the lifespan (Hamilton *et al* 2015).

Shoulder injury incidence and severity

The incidence of time-loss shoulder injuries reported at the highest playing level (international cohort) ranged from 5.8 per 1,000 hours in the 2015 Rugby World Cup (Fuller *et al* 2017) to 33.8 per 1,000 hours sustained by Welsh international players across a three-year period from 2011 to 2014 (Moore *et al* 2015). The findings in the latter study are unprecedentedly high in relation to all other data on shoulder injuries for adult rugby players, this is accredited to the rigorous data collection process and other methodological issues. Players at the professional level sustained shoulder injuries that ranged from 7.26 per 1,000 hours in New Zealand premier club players to 16.5 per 1,000 hours in South African super rugby teams (Schwellnus *et al* 2014). It is noteworthy that the incidence of shoulder injuries reported in the former study included both time-loss and medical attention where more time-loss injuries (n=104) were reported than medical attention (n=60) for all injuries (n=164). A somewhat lower incidence of time-loss injuries for adults was reported in the lower playing levels, i.e. semi-professional, amateur and recreational, and ranged from 2.3 per 1,000 hours in a prospective cohort study (Roberts *et al* 2013) to 7.3 per 1,000 hours (Swain *et al* 2016). In another prospective cohort study of Australian players, however, the latter study combined time-loss and medical attendance for the reported shoulder injuries. The findings from these studies indicate that the highest incidence of time-loss shoulder injuries is seen at the higher playing levels in adult men.

In a recent retrospective study, conducted over the seasons 2012 to 2015, English academy youth players (n=132) had the highest shoulder injury rate among junior players with 19 per 1,000 hours (Barden & Stokes 2018). This was higher than the injury incidence

> "SHOULDER SPRAIN AND DISLOCATIONS HAVE A RELATIVELY HIGH RATE OF RECURRENCE"

at the highest playing level for the junior players at the U-20 Rugby World Cup, which was 9.09 per 1,000 hours reported over eight seasons (Fuller *et al* 2018). Academy players in England also sustained the highest incidence of upper limb injuries at 25 per 1,000 hours, when comparing elite youth to non-elite. Interestingly, the highest proportion of shoulder injuries was also previously reported for this playing level at 28.4% between 2006 and 2008 (Palmer-Green *et al* 2013). It is concerning to observe that since 2008 shoulder injury rates have increased in academy players, and from then to 2015 these players sustained a higher incidence of shoulder injures than professional adult players.

Shoulder dislocations was the highest injury burden for English professional players, accounting for 1,703 days absence from play (Headey *et al* 2007) and, although it was the second highest injury burden for the U-20 Rugby World Cup players, it accounted for 2,865 days absence (Fuller *et al* 2018). The greatest number of days lost in English schoolboy players was also due to shoulder dislocation / instability, accounting for 986 days lost (Palmer-Green *et al* 2013). Injuries to junior players, at a time when they are undergoing major physiological developments, can have considerable consequences particularly from high levels of exposure (Caine *et al* 2006; Maffulli *et al* 2010).

Shoulder injuries in sport effect numerous direct and indirect levels, such as the biological effects on the injured tissue, absence from training and match play, long-term health consequences and financial cost. There are numerous determinants of the impact that a shoulder injury can have, ranging from the player's age at the time of injury, type of injury, i.e. traumatic versus non-traumatic, recurrence of injury, the time elapsed between injuries, and the type of intervention or management options taken (Hovelius & Saeboe 2009; Mohammed *et al* 2014).

Financial implications

The consequences of a sport injury may have a direct physical and psychological health cost to the injured player, who may also incur healthcare costs and other indirect expenses (Cumps *et al* 2008). Financial costs may be grouped into direct costs which include those related to treatment and rehabilitation, whereas time away from work / education and childcare are considered indirect costs (Collard *et al* 2011). In a study looking at the economic burden of youth rugby injuries (n=190), Brown *et al* (2014) found the cost of medical follow-up treatment to be US $731 per injury. Upper extremity injuries and fractures resulted in the highest costs, based on time-loss definition, for players who had medical insurance compared to those that did not (US $1,242; with a 95% confidence intervals of between US $445 to $2,269). Furthermore, severe injuries may also result in an extended course of rehabilitation which could influence time away from work / education. The extent of injuries is far reaching, extending beyond the monetary cost and can also impact on occupational responsibilities.

Injury type

In a contact sport like rugby where collisions are inevitable, acute injuries are most common to the shoulder. Studies show that injuries to the acromioclavicular joint (ACJ) were the most frequent in professional rugby union players ranging from 2.86 per 1,000 hours (Headey *et al* 2007) to 3.7 per 1,000 hours (Usman *et al* 2015), and were also most common in a cross-section (n=1,475, elite professional, professional club level and under 20 elite players) of competition playing levels (Usman & McIntosh 2013). Shoulder sprain and dislocations accounted for the longest time off the field in all age categories in French rugby union players (Bohu *et al* 2015) and also in South African premier rugby players (Lynch *et al* 2013). This has been seen to jeopardise a player's future career (Brophy *et al* 2011). These injuries were also reported as having a relatively high rate of recurrence at 36% in adult community players (Singh *et al* 2016). By contrast, a low rate of recurrent instability has been seen in players following rehabilitation with the Latarjet-Patte technique. At 12-year follow-up, 65% were shown as having returned to rugby without recurrence of injury (Neyton *et al* 2012). Though surgery offers some players an opportunity to return to sport, the significant implications of shoulder injuries is evident among English professional rugby union players, where it is reported to be the most common reason for retirement in the previous 10-year period (Brooks *et al* 2005). Exposing the significant consequences of shoulder injuries, specifically at a young age, implores more focused efforts to reduce this associated risk.

Mechanism of injury

This injury data helps to identify which injuries are most common and requires further investigation to determine how these injuries occur. The tackle was the most common injury mechanism for all injuries across all playing levels and shown to be a significant risk factor for acute shoulder injuries (Fuller *et al* 2010, Fuller *et al* 2007). Tackling or being tackled was equally reported as the most common inciting event for all injuries in adult and youth players. Multiple factors play a role in the resultant injuries caused by the tackle, one of which is tackle technique (Burger *et al* 2017). Video analysis studies of tackles in elite rugby players illustrate that forcibly levering the tackler's arm backward, i.e. >90^0 glenohumeral abduction, horizontal abduction and, in some cases, external rotation at the point of impact with the ball carrier, leads to dislocation (Crichton *et al* 2012; Longo *et al* 2011; Maki *et al* 2017; Usman *et al* 2015).

Other common mechanisms reported include the try scorer injury which occurs when diving and reaching the ball carrying hand forward to score a try, the shoulder may subluxate or dislocate, resulting in a Bankart lesion, superior labrum anterior-posterior lesion (SLAP) or rotator cuff lesion (Crichton *et al* 2012; Usman *et al* 2014). When tackling an opponent, anterior dislocation is most common with the risk of a Bankart lesion, SLAP or humeral avulsion of glenohumeral ligament (HAGL). Direct shoulder impact with the ground or another player can involve a combination of bony glenoid lesions, complex labral tears or a rotator cuff lesion. A posterior driven force from falling onto a flexed elbow can result in posterior labral tears, reverse HAGL.

The findings from these studies help to identify a number of common mechanisms that may contribute to acute shoulder injuries in rugby. Understanding the mechanisms of injuries can guide the rehabilitation and prevention options in sports where high collision forces are common. Players should be taught to avoid vulnerable arm positions when tackling and when coming into contact with the ground to minimise the risk of injury. In addition, other researchers proposed that a well-conditioned player may better withstand the impact of the tackle, thereby minimising their injury risk (Gianotti *et al* 2009; Horsley & Herrington 2014).

Risk factors

Identifying the aetiological factors contributing to injury risk (figure 1) is deemed to be an important step in the sport injury prevention frameworks (Finch 2006; van Mechelen *et al* 1992). Few studies have investigated intrinsic risk factors for shoulder injuries in rugby

MODEL STAGE	SEQUENCE OF PREVENTION	TRIPP
1	Injury surveillance	
2	Establish aetiology and mechanisms of injury	
3	Develop preventive measures	
4	Ideal conditions/ scientific evaluation	
5		Describe intervention context to inform implementation strategies
6		Evaluate effectiveness of preventive measures in implementation context

FIGURE 1: The 'sequence of prevention' and the Translating Research into Prevention Practice (TRIPP) framework

and, unsurprisingly, preventive attempts to address these risk factors are lacking in the literature. Glenohumeral laxity and instability, reduced shoulder external rotation strength (Cheng *et al* 2012; Ogaki *et al* 2014; Stewart & Burden 2004), shoulder range of motion deficits (Fernandez *et al* 2011) are some of the risk factors that are shown to be associated with shoulder injuries in rugby players. Aetiological research is complex, often requiring additional resources and faced with greater logistical and administrative challenges (McBain *et al* 2012). Furthermore, a key limitation of screening for risk factors is that they are unlikely able to predict injury (Bahr 2016).

Injury prevention

The understanding gained from the descriptive and analytical injury research is used to inform the development and evaluation of preventive strategies. Rugby injury prevention research has targeted catastrophic injuries to the head and spinal cord by improving coaching standards and amendments to the law of the game (Brown *et al* 2016; Cazzola *et al* 2014; Gianotti *et al* 2009; Patricios 2014; Quarrie *et al* 2007). Preventive neuromuscular training as part of a warm-up routine has shown to be efficacious in preventing injuries in other sports (Emery *et al* 2015; Thorborg *et al* 2017) and attempts have been made to reduce shoulder injuries in overhead sport (Andersson *et al* 2017). Similar preventive neuromuscular training programmes have been evaluated in schoolboy and adult community rugby and shown to reduce the incidence and burden of rugby-related injuries (Attwood *et al* 2018; Hislop *et al* 2017).

There is however no "one size fits all" for injury prevention and what works in one context may not work in a different setting. Implementing preventive strategies in elite adult rugby may not be applicable to all playing levels, such as community youth rugby. Current research asks for the implementation context to be described, allowing for important barriers and facilitators to adoption and sustainability of prevention measures to be understood (Donaldson *et al* 2017; O'Brien & Finch 2014). There is a recognised knowledge gap in the research into sport injury prevention; there is little known about the reasons for any uptake, or lack of adoption to an intervention as studies merely state that the intervention did or did not work. Consideration also needs to be given to the individual safety behaviour that influences adoption by the multiple factors such as the form of delivery, who delivers the intervention and the broader ecological context. Individuals are influenced by the groups they belong to and, in the youth community rugby setting, it is important to understand the influence that this may have on the adoption of the intervention.

"INJURY DATA HELPS TO IDENTIFY WHICH ARE MOST COMMON AND REQUIRES FURTHER INVESTIGATION INTO HOW THEY OCCUR"

"THERE IS NO 'ONE SIZE FITS ALL' FOR INJURY PREVENTION"

Reviewing how interventions have been developed offers further insight into the reasons for the outcomes achieved of the intervention.

Conclusion

Shoulder injuries have been shown to be among the most common injuries reported in rugby across all playing levels irrespective of the injury definition used, and they account for the greatest number of days absent from match play. The impact of shoulder injuries is considerable and extends beyond the physiological level, threatening the players' and stakeholders' financial and social aspects to a point which merits investigation. A key omission from the literature is the study of focused interventions aimed at reducing the risk of shoulder injuries in rugby players, these are an under-investigated feature of existing injury prevention measures.

About the author

Vincent Singh works full-time as a senior lecturer at the University of the West of England in Bristol. He is also busy with doing a PhD part-time at the University of Bath and his research topic is "Shoulder injury prevention in rugby union". Vincent was successful in receiving a research award from the Private Physiotherapy Educational Foundation to enable him to pursue this research. Previously, he worked part-time in private practice managing musculoskeletal conditions.

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Keeping in touch with technology: the potential of robotic therapy for upper limb rehabilitation following stroke

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The rapid pace of technological development has an ever-increasing influence on contemporary society. In recent years, healthcare policy in the United Kingdom has placed an emphasis on individualised care, the use of technology and the impact of long-term conditions across the population. While the use of robotic therapy can positively influence the recovery of arm function, in terms of motor impairment, following stroke in acute, and particularly in chronic stages of rehabilitation, evidence supporting impact on activities of daily living is not clear. Robotic therapy should be understood in the context of not being a replacement for physiotherapy, and this article seeks to provide an overview of how it can offer a safe, effective and efficient adjunct to rehabilitation in the upper limb following stroke.

LEARNING OUTCOMES
TO SUPPORT PHYSIO FIRST QAP

1 Appreciate the difficulties with adherence to self-managed rehabilitation in the stroke population.
2 Understand that technology can aid cost-effective treatment.
2 Be aware of the technology available to assist stroke rehabilitation and meet patient goals.

Introduction

Stroke is a leading cause of adult death and disability in the United Kingdom with approximately 57,000 first-time strokes occurring in 2016 alone (Gov. UK 2018). A stroke can be defined as an interruption in blood flow to the brain from a clot or internal bleeding, resulting in partial loss of brain function (WHO 2010; Prange *et al* 2006). The destruction of cortical tissue leads to damaged generation and integration of neural commands in which motor, sensory and / or cognitive functions are affected (Prange *et al* 2006; Loureiro *et al* 2003). While there are around 32,000 stroke-related deaths in England each year, death rates related to stroke have declined by 49% in the past 15 years (Gov.UK 2018). This decline has been accredited to a combination of better prevention, earlier treatment, and more advanced treatment and rehabilitation.

For those who are affected by stroke, ongoing motor impairment and limited function is more common in the upper limb, which has led to recommendations for more effective therapies (Alankus *et al* 2011). This article seeks to provide a broad overview of rehabilitation related to robotic therapy (RT) involving the upper limb. Evidence-base in relation to RT will be highlighted in identifying benefits and possible limitations for this exciting area of stroke rehabilitation.

Over the past 20 years, technology has had an increasing impact on 21st Century living in general with continuing advancements influencing the NHS to place a high priority on digitalisation. Over the past five years, successive policy has placed emphasis on individualisation for person-centred care, the use of technology in healthcare, and long-term conditions such as stroke (NHS England 2014, 2017; NHS 2019).

Motor impairments affect about 80% of people following stroke (Alankus *et al* 2011) with 75% left with permanent disability (Kan *et al* 2011). A broad range of motor functions can be affected, often across an entire side of the body with impairment being more common in the upper limb. Approximately two-thirds of stroke victims are affected in this way, with only 50% recovering function (Mehrholz *et al* 2012; Loureiro *et al* 2003). It is thought that less time spent working the upper limb and decreased spontaneous use could influence this (Sabini *et al* 2013). As long ago as 2005, Daly *et al* believed it vital to develop more effective upper limb restoration methods. In essence, this was the rationale for developing resources such as the InMotion Robots (figure 1) (Bionik 2019).

"MOTOR IMPAIRMENTS FOLLOWING STROKE ARE MORE COMMON IN THE UPPER LIMB"

Conceptualisation of movement and upper limb rehabilitation

A defining characteristic of physiotherapy is in the conceptualisation of movement from a micro- to macroscopic level through a continuum of movement (Cott *et al* 1995). Movement is promoted as an interdependent phenomenon that links sub-molecular movement to the interaction of a person within the society they live. It is further proposed that a physiotherapist's role is to minimise the difference between current and preferred movement capability for an individual. The physiotherapist is a "skilled companion" (Higgs & Titchen 2001) in developing therapeutic relationships for individualisation of care. Therefore, a physiotherapist within stroke rehabilitation seeks to increase independence and participation in daily activities by focusing on a person's preferred movement.

Altered upper limb function following stroke can affect an individual's ability to perform activities of daily living (ADLs), such as reaching to grasp objects, and self-care activities (Alankus *et al* 2011; Prange *et al* 2006; Jackson *et al* 2011). An inability to perform a skilled functional activity smoothly, or at all, can lead to the development of compensatory strategies, for example use of the trunk and less-affected limb to complete functional tasks (Nudo & Duncan 2004).

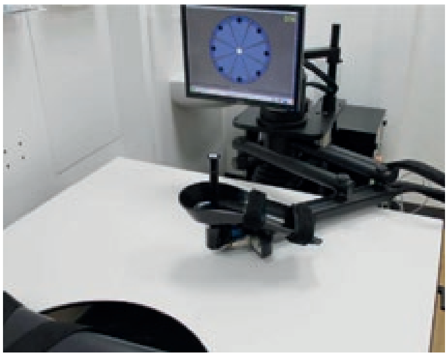

FIGURE 1: InMotion robot device

Taub *et al* (1993) suggested that this could lead to "learned non-use" of the affected limb. Rehabilitation is therefore important in attempt to decrease impairment and regain a preferred level of movement.

Effective approaches to improve upper limb motor function includes high-intensity, repetitive, task-specific and goal-directed rehabilitation (Backus *et al* 2010; Fasoli *et al* 2004). Intensive training promotes cortical reorganisation to help overcome the learned non-use of the impaired limb (Brewer *et al* 2007). Repetitive exercise can provide stimuli to help the nervous system remodel itself through plastic adaptation (Alankus *et al* 2011; Hogan *et al* 2006). Several hundred daily repetitions may be required to make progress (Selzer 2006) that may, in turn, require one-to-one interaction and physiotherapy for an extended period of time (Huq *et al* 2011; Kan *et al* 2011; Prange *et al* 2006). Self-managed exercise programmes are commonly employed to supplement intervention. However, it has been claimed that as few as 31% of individuals perform these exercises (Shaughnessy *et al* 2006), which may well be an obvious consequence of the extreme difficulty highly impaired patients have with self-management and their limitations with regard to many high repetition modalities (Finley *et al* 2005).

Robotic therapy and upper limb rehabilitation

Robotic therapy (RT) can be described as a technological intervention, in development, to providing repetitive rehabilitation. It has been defined as "the application of electronic computerised control systems to mechanical devices designed to perform human functions" (Kwakkel *et al* 2008). In relation to stroke rehabilitation, the patient is assisted with movement by the computerised system.

Broadly speaking, current available evidence would indicate that RT is tolerated well and enjoyed by patients and viewed positively by physiotherapists (Stephenson & Stephens 2017; Liddell *et al* 2008, Lee *et al* 2005). Robotic technology is viewed as an adjunct to physiotherapy (Stephenson & Stephens 2017), rather than a replacement (Loureiro *et al* 2011).

There are two main types of rehabilitation robots:

1. End-effector systems that interact with the patient using a single distal attachment, and

2. Exoskeletons that encapsulate the arm to control the orientation of the limb (Loureiro *et al* 2011).

Exoskeletons are worn by the patient and replicate the human skeleton through various links and joints (Pignolo 2009). They allow full, spatial, multi-joint function and provide contact along the entire limb, much like a therapist might do (Frisoli *et al* 2012; Carignan & Krebs 2013). It has been noted by Chang & Kim (2013) that there is insufficient evidence to draw conclusions for exoskeleton devices on upper limb function, but end-effector systems yield greater results, especially when working with people with "chronic stroke" conditions.

The principle of RT is in the potential for intense repetitive training (Scott & Dukelow 2011) with little or even no supervision (Harvey 2009; Kwakkel *et al* 2008). Unlike humans, robots do not fatigue (Harvey 2009) and can therefore follow an intensive programme, often within a group environment (Norouzi-Gheidari *et al* 2012; Brewer *et al* 2007).

"AS FEW AS 31% OF INDIVIDUALS ADHERE TO A SELF-MANAGED STROKE REHABILITATION EXERCISE PROGRAMME"

Perceived benefits

The benefits of RT are well cited. They include improvement in biomechanical factors and in increased active movement related to impairment (Rodgers *et al* 2019; Bertani *et al* 2017). These benefits may also hold implications for reduced strain on therapists (Huq *et al* 2011) in their challenge to provide intensive treatment for all patients (Volpe *et al* 2002), provide an increased motivation for recipients, in the opportunity for independent exercise (Hughes *et al* 2011), and in "ready-made" outcome measures (Frisoli *et al* 2012). In terms of workload and skill mix, robots may enable physiotherapists to spend more time with more complex interventions and increase overall therapy by freeing up higher-grade staff time for the provision of effective and efficient intervention, and better use of available resources (Stephenson & Stephens 2017; Porter 2013; Jackson *et al* 2011).

From a patient perspective, increased motivation towards rehabilitation has been described. Robotics appear more interesting and this can positively influence participation (Norouzi-Gheidari *et al* 2012). The use of games may also increase participation by integrating repetitive practice into an engaging task (Kwakkel *et al* 2008). Robots are, therefore well tolerated by the patient, which encourages motivation. The improvement gained from this form of rehabilitation is visually represented via outcome measures that are being constantly recorded (Mehrholz *et al* 2012; Loureiro *et al* 2011).

Possible limitations

Two key areas that are consistently raised within the literature regarding RT are:

1. Challenges to quality of movement in independent exercise. This is possibly due to robots being unable to detect fatigue in the patient (Kwakkel *et al* 2008; Barnes *et al* 2011). Related to this is the concern that patients working with active-assisted protocol that is available with some robots may learn to wait until the robot performs the task for them (Norouzi-Gheidari *et al* 2012). In a sense, the movement would then become passive and may not stimulate neural commands, meaning little to no adaptation would take place.

2. Rodgers *et al* (2019), Bertani *et al*, (2017), Scott & Dukelow (2011) among others have questioned functional relevance of robots in relation to impact on ADLs. However, as highlighted earlier (Stephenson & Stephens 2017), robots are not designed to replace physiotherapists, but to improve biomechanical factors (Loureiro *et al* 2011; Fasoli *et al* 2004). Indeed, at present it probably should be accepted that not all patients may benefit from RT, as some robots are designed to facilitate gross movements, particularly of the shoulder and elbow (Brewer *et al* 2007), that may not be reflected in a significant improvement in function. Thus, as with any physiotherapy intervention, thorough clinical assessment, dialogue and goal setting with regard to patient preference is required.

Within the chronic setting, a number of articles such as Volpe *et al* (2008), Finley *et al* (2005), Fasoli *et al* (2004), and Stein *et al* (2004) have reported RT being applied in isolation. The UK recommendation is for RT to be used as an adjunct to conventional therapy (Intercollegiate Stroke Working Party 2012). Thus, it may be argued that there exists a research-practice gap, as it is common for research trials in this area, e.g. Rabadi *et al* 2008; Volpe *et al* 2000 to compare RT with "usual care", with often a proportion of the sample receiving "usual care" alongside RT as one of the intervention groups. This may introduce co-intervention bias that, ironically, leads to the recommendation / rationale for RT. Therefore, it may be suggested that, due to the nature of randomised controlled trials, RT may not be used as proposed and could contribute to an explanation as to why ADL tasks are often not observed.

It must also be recognised that performance of activities of daily living require both proximal and distal control of the limb (Scott & Dukelow 2011), and not all robots have provision for this. Additional therapy in accordance with current recommendations of RT as an adjunct would therefore need to take place. Indeed, comparison studies involving a physiotherapist to match exercise intensity have provided similar improvements as RT (Lo *et al* 2010; Volpe *et al* 2008). However, it is worth remembering that one of the purposes of RT development is in order to increase the efficiency of the therapist intervention (Stephenson & Stephens 2017).

Where we are now

It is interesting that nine years ago Backus *et al* (2010) stated that, although RT provides the opportunity for high repetition movement in the facilitation of plastic adaptation, the exact role in clinical care remains uncertain due to research in the area being fairly limited. However, the research base is continuously expanding and in their 2012 Cochrane Review Mehrholz *et al* suggested that RT could improve generic activities of daily living. A more recent review and meta-analysis (Bertani *et al* 2017) sought to assess the effectiveness of different robotic devices, i.e. end-effector and exoskeleton, in comparison with any other type of intervention. A total of 17 studies comprising randomised controlled trials, systematic reviews, and one meta-analysis were included, the overall findings of which were that, in comparison with conventional therapy, RT is more effective in improving upper limb motor recovery, particularly in chronic stroke

> "ROBOT TECHNOLOGY CAN POSITIVELY INFLUENCE PATIENT PARTICIPATION IN THE REHABILITATION PROGRAMME"

> "ONE OF THE PURPOSES OF ROBOT TECHNOLOGY DEVELOPMENT IS TO INCREASE THE EFFICIENCY OF PHYSIOTHERAPY INTERVENTION"

patients. No significant improvements were found in the reduction of muscle tone or ADLs. A recently published multi-centre, randomised controlled trial (Rodgers *et al* 2019) compared robot-assisted training with an enhanced upper limb therapy programme-based repetitive task practice and with "usual care". Robot-assisted training and enhanced upper limb therapy was not found to improve upper limb function for patients with moderate or severe functional limitation of the upper limb following stroke.

Conclusion

The evidence for the use of robotic therapy would seem to indicate that it can positively affect the recovery of arm "function" and has demonstrated to be effective in improving upper limb motor activity in the rehabilitation stages of both acute, and particularly chronic stroke patients (Bertani *et al* 2017). It is acknowledged that RT is not a replacement for physiotherapy, but that it offers a safe, effective and efficient additional option for therapy.

In relation to functional ADLs, RT is recommended as an adjunct to rehabilitation. The physiotherapist, as part of a multidisciplinary team, plays an important role in utilising their knowledge, skills and understanding of movement as an interdependent continuum characteristic of life and being, to support individuals in achieving their preferred level and quality of movement. As with any aspect of life, RT offers exciting possibilities for both patients and therapists, but it may also on occasion be a little frustrating!

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The field of robotics will undoubtedly continue to develop, and it is suggested that physiotherapists, and rehabilitation in general, need to be in a position to make best use of this technology as it becomes available. It is necessary to continue to think differently in terms of potential benefits to the patient and, although not discussed within this paper, to consider assessing the cost of initial outlay, storage, maintenance, training for the access to such technology against the opportunity for improved, and more efficient, outcomes. As with any successful intervention, RT provision is dependent on human relationships, to provide safe, effective and efficient rehabilitation, with open therapeutic relationships being vitally important to provide an individualised focus.

About the authors

Dr John Stephens is a Senior Lecturer and Faculty Director of Teaching and Learning (Programme Development, Approval and Review) in the Department of Sport, Exercise and Rehabilitation at Northumbria University.

He began his clinical career in the Royal Navy and the NHS, mainly working in rehabilitation, including cardiac, pulmonary, stroke and in older people's services. He also has worked in the area of acute medicine. In the late 1990s John moved to the post of Senior Lecturer-Practitioner at Gateshead – Northumbria University where he worked for five years before moving in early 2000 to full-time academia. Although his research interests lie mainly in curriculum development, John continues to maintain links in clinically-based research.

Andrew Stephenson graduated from the University of Sunderland in 2011 with a BSc (1:1) in Sport and Exercise Science. He went on to graduate from Northumbria University with a MSc in Physiotherapy (Distinction) in 2015.

Andrew's Master's Dissertation was later published as "An exploration of physiotherapists' experiences of robotic therapy in upper limb rehabilitation within a stroke rehabilitation centre" and was also presented at numerous conferences around the country.

Andrew is currently working at Northumbria Healthcare Trust as a Specialist Respiratory Senior Physiotherapist.

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Honorary Memberships

Three given well-deserved recognition

At our AGM earlier this year, three of our outgoing executive members were presented with Honorary Life Membership of our organisation. Here we highlight why Pam Simpson, Amanda Marsh and Paul Johnson received such well-deserved recognition of all they do for, and on behalf of, Physio First.

Pam Simpson

Pam's Honorary Life Membership is awarded in recognition of her leadership as an executive committee member in consecutive roles of Hon. PR Officer, Vice Chairman and as our outgoing Chairman. In her role as Chairman, Pam helped to define our Physio First strategic intent, develop our formal communication strategy, hone our unique and strategically aligned member benefits – most notably our unique Quality kite marks – and was key in the migration of our *Update* newsletter from print medium to the digital The Core.

In addition to this, Pam positively nurtured strategically important relationships with the CSP, PPEF, IPPTA, the Quality in Private MSK Working Group, as well as with our colleagues in the Irish Chartered Physiotherapists in Private Practice organisation.

Pam's leadership has touched, and positively and successfully influenced every part of our organisation. Her service to Physio First in particular, and to the physiotherapy profession in general, has been considerable.

Amanda Marsh

Amanda has made an outstanding contribution to Physio First from the start. In 2008 she took on the role of Regional Officer for London and took part in our executive meetings with enthusiasm and represented her local members admirably. Her growing involvement as an active part of, and subsequently Chairman of, our education committee resulted in Amanda, with our hardworking team of volunteers, successfully delivering a number of impressive and highly respected conferences.

As her role evolved, Amanda led the delivery of our Physio First education strategy to support our Quality agenda. Amanda's excellent people skills have enabled the smooth progress of this process, and her relationship with her team members has been pivotal in this success.

Paul Johnson

It was a great pleasure for Physio First to award Paul his Honorary Life Membership. For 18 years, Paul has been an active member of our editorial sub committee, where he has been instrumental in delivering our journal, *In Touch*. For the past six years, he has held the role of Editor, during which time he steered *In Touch* through our rebranding exercise with energy and enthusiasm.

His reputation and experience with regard to education and evidence-based practice inspired well-known and widely respected authors to contribute to our journal and his own passion for our Physio First Data for Impact resulted in Paul being one of our first cohort of Quality Assured Practitioners, and translated to the articles produced in *In Touch*.

Paul's natural leadership and readiness to take every opportunity to champion our strategic direction, and the physiotherapy profession in general, means that he is a valuable member of Physio First.

Obituary

Remembering Alan Bonelle
1927-2019

It is with great sadness that we report the death, on 1 June 2019, of Alan Bonelle.

Alan joined the then OCPPP in December 1971 and, in 1973, he became Regional Officer for Mercia, a role he held for 14 years. In 2003, Alan took on the role of Vice President of Physio First and continued in that post until 2007, despite retiring from practice in 2000.
Alan was always an enthusiastic advocate for our organisation and for private physiotherapy practice in general, and our thoughts are with his family at this sad time.

Hints and tips on data collection

from the Physio First research and development team

Being part of the Physio First and University of Brighton Data for Impact (DfI) scheme enables you to evaluate the efficacy of your practice and helps us, at Physio First, to champion private physiotherapy to our stakeholders and patients. If you're not sure what collecting data entails, here are some pointers to help you get started, or to streamline what you are already doing.

Involve your team. If you have a reception and / or admin team, some data such as patient details and referral information can be inputted by them to help free up your time and get you started. You can then access that patient's data on the website and continue with inputting when you have time.

Assessment of Functional Physical and Subjective Outcomes (FPS) sheet. Print (or laminate) a copy of this page. Give this copy to your patient before they enter the treatment room and ask them to consider where they might be on the scale. Patients generally mark themselves with a lower score than is apparent when the subjective information emerges. The final score needs to be discussed between you and the patient. Remember to use the most relevant aspect of their problem, e.g. sleep or pain level etc., when measuring the score. No patient will fit all the criteria.

Keep an eye on your emails. The University of Brighton sends "top tips" emails with hints and tips on data collection. They are worth reading!

Be aware of your **waiting times**, i.e. the time between the patient requesting a date for an appointment and being seen by a physiotherapist. Record the date the appointment was made and, in instances such as the patient requesting an appointment in advance of surgery, or on returning home from a holiday, their preferred appointment date in the clinic diary. Such details make it easier to see if the patient has had to wait for a requested appointment date. Also, consider developing a code to identify whether the patient declined the offer of an earlier appointment, as this may be an influencing factor to account for any delay in seeing the patient.

Remember to use the **Influencing Factors** tab to list anything that could affect the outcome of your treatment. There are 27 factors, including difficulty with childcare, natural progression, exacerbation of condition and time since onset.

To make best use of the **Resources tab**, log on to DfI tool on the University of Brighton website. The first page of the DfI tool gives you access to the following resources:

- Patient Information Sheet
- Patient Consent Form
- User Guide
- FPS scale – for you to print out and use in the clinic
- BmPROM
- BmPROM supplementary information

Make the most of **The User Guide**. If you were given your login details some time ago the version of The User Guide you were sent then may not be current. You can download an updated one from the Resources tab (mentioned above).

… and an important tip for QAP / QAC applicants who also need to collect and submit validated patient recorded outcome measure (PROM) data:

Get your patient to **complete the PROM** prior to entering the treatment room. This could be the paper version or the online form via computer, laptop or mobile device. Alternatively, email the link to an online PROM for the patient to complete prior to coming to your clinic.

Did you know that any validated PROM is accepted for our QAP / QAC scheme? However, if you would like to use the University of Brighton's own online bmPROM, please contact **physiosurvey@brighton.ac.uk** for instructions and login details. Please note that it is currently not possible to input the BmProm to the DfI system as they are two separate systems.

In addition, the Physio First website hosts a comprehensive list of FAQs that can be found here: **https://www.physiofirst.org.uk/resources/public-faqs.html**

If you have any of your own useful, time-saving tips for members who are collecting data through DfI and / or are working towards QAP and QAC, please share them by email to: **minerva@physiofirst.org.uk** for the attention of R&D.

Tips from our team

Exciting news about other payment options will be announced shortly... Please look out for e-alerts

Renew your membership by direct debit

Paying for your Physio First membership by direct debit means that you never have to worry about when your subs are due. In addition, full and affiliate members who pay by direct debit will save £10 on their annual subscription.

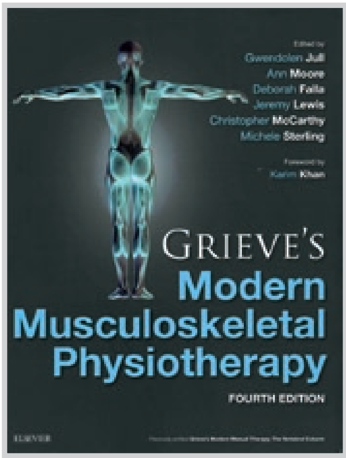
If you don't already have a direct debit instruction in place, you can set one up now to be active in time for 2020.

Download a direct debit form on our website www.physiofirst.org.uk
- Log in with your membership number and password
- Click on My Physio First
- Click on Renewals
- Scroll down to Direct Debit Instruction where you can print off a form to complete and return to the Physio First Head Office.

If you do already have a direct debit, but your bank details have changed since 1 April 2019, you may need to submit a new instruction to us. All new and replacement direct debit instruction forms must be signed and be with our membership team at **Physio First, Minerva House, Tithe Barn Way, Swan Valley, Northampton NN4 9BA** by **20 February 2020**. Forms received after this date will be too late for the 2020 renewal process and so will not qualify for membership discount.

Book review

Grieve's Modern Musculoskeletal Physiotherapy (4th edition)



Editors: G Jull, A Moore, D Falla, J Lewis, C McCarthy, M Sterling
Publisher: Elsevier | ISBN: 9780702051524 | RRP £99.99

This publication has no intention of resting on its laurels! For this fourth edition, the royalty of the physiotherapy world has gathered to deliver a textbook of distinction, that must be an essential tool in the armoury of every physiotherapist.

Its 672 pages are crammed with the latest knowledge about research developments, principles of patient management, contemporary issues in practice, and discussions on the future direction of our profession.

Each chapter is written by a genuine innovator and expert in their field of practice, and always with the clinician at the forefront of their thinking. This means the text is easily applicable for any working physiotherapist.

I have no hesitation of recommending this book to anyone wishing to improve their knowledge and enhance how they approach their everyday practice.

Tobias Bremer

Introducing our new Book Editor for *In Touch*... **SUSANNAH SOLT** has taken on the task of Book Editor from our now Editor, Tobias Bremer. Susannah is a member of our Education sub committee and would be interested in hearing from you if you would like to write a review of any physiotherapy-themed book you have recently read or know of that might be of benefit to our members. You can contact Susannah at susannah@activenowphysio.com

Small ads

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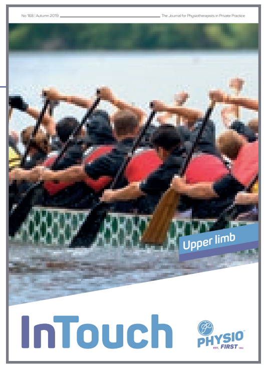

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