THROWING IS THE MOST IMPORTANT THING HUMANS HAVE EVER DONE!

BUT… "BASEBALL IS A BIG PART OF INJURIES" - YOGI BERRA

– Written by Rodney Whiteley, Qatar

Arguably, the ability to throw for hunting, attacking and defending has been a principle driver of the success of humans as a species (see p 268). Perhaps I am a barracker for throwing. Actually, I have been since I first experienced the thrill of making a long throw accurately hit its target. Most people have experienced a similar feeling standing next to a lake with a good supply of flat skipping stones at the ready. Such occasional throwing for modern humans is fun, but rarely will it determine how much food you will eat. Except of course in the case of the professional throwing athlete who, like his pre-historic antecedent, is able to gather the spoils of throwing success (fame, fortune, lifestyle, an eager list of potential suitors) from the ability to accurately, forcefully and repeatedly throw. These days, instead of hunting and fighting, such throwing is more limited to the sporting arenas of baseball, handball, javelin, water polo, volleyball and tennis etc.

Performing repeated forceful throws occupationally gives rise to some peculiar injury and adaptation in the throwing athlete. These vary from almost any other shoulder or arm injuries you are likely to see in other contexts. The norm for shoulder injury in modern humans is not throwing-related, so those who do not work regularly with this group are likely to use their other experience in examination and rehabilitation to infer that similar mechanisms are at play and therefore similar treatment can be successfully applied. In this brief summary, I plan to avoid areas of agreement and put forward a number of controversial ideas relating to these differences including the following:

- There is no anterior instability in the throwing shoulder.
- Labral injuries are not what you think.
- Rotational range of motion is important to understand.
- That you should be measuring strength in these athletes.

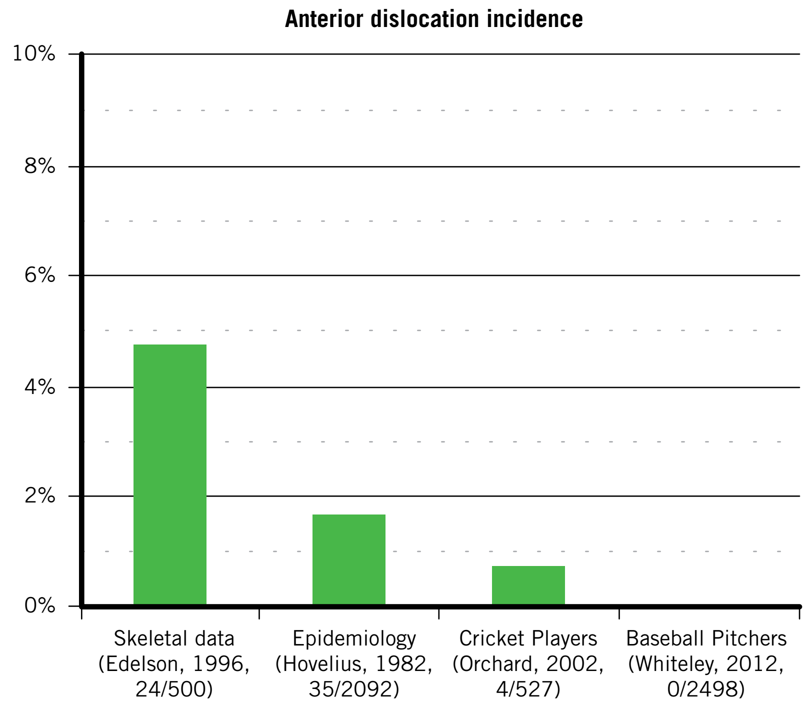

Figure 1: Prevalence of shoulder dislocation according to throwing ability. The skeletal and epidemiologic data is from modern-day "normal" adults who can be considered, on average, to be non-expert throwers. Likely the epidemiologic data is underestimating the true incidence somewhat. Cricket players do some throwing, but it's not primary in their sport, and the throwing arm of Major League Baseball professional pitchers can be considered some of the most highly trained throwers in existence. The data is clearly showing that the better you are at throwing, the less likely you are to dislocate your shoulder.

THERE IS NO ANTERIOR INSTABILITY IN THE THROWING SHOULDER

As throwing athletes will regularly describe pain at the 'cocking' phase of throwing, with their arm abducted and externally rotated, it was a short leap to suspect that the pain these players were feeling most likely had a similar mechanism to the pain felt during an anterior dislocation, which also happens at roughly the same arm position. The players never relate that their shoulder actually frankly dislocates during a throw. The thought was that these athletes, through forceful repeated movements to abduction and external rotation were suffering a 'microinstability'[1] wherein their shoulder was being stretched to the point of dislocation – translating anteriorly or even subluxing slightly – and then relocating back into the joint. This transient but repeated movement was therefore suspected as the cause of their pain. It is worthwhile examining this notion a little more closely.

Firstly, if it were true that the principal mechanism of the throwing athlete injuring their shoulder was such subtle repeated anterior translation, then it stands to reason that this will be occurring to a greater or lesser extent in many, if not all, of these athletes. Accordingly, some will experience only a small amount of asymptomatic translation whereas at the other extreme there would be subluxations up to the occasional frank dislocation. We could therefore expect to see a higher rate of dislocation in those who throw the most.

With this in mind I consulted Major League Baseball's repository of injury data, the 'Disabled List' wherein players who are required to be replaced from the team's 25-man roster must provide a medical reason and an expected time-frame[2]. In this data set I only looked at those players who do the majority of throwing and certainly the majority of maximum effort throwing, the pitchers, and for them I only considered their throwing arm. For comparison, we need a population who do little throwing. Here we can look at demographics of otherwise healthy adults as documented in Sweden[3], as well as skeletal data[4] which would appear to pick up more shoulder dislocations. The rates of shoulder dislocation in 'normals' then seem likely to be somewhere in the magnitude of about 2 to 4%. For throwing comparison, I considered a sport that has throwing as a requirement, but a somewhat minor component of the game: cricket[5]. So here we have, I think, a continuum from "not much throwing" to "some throwing" to "as much throwing as people can possibly do" (Figure 1).

Rather than seeing an increase in shoulder dislocation incidence as the amount of forceful repetitive throwing increases, we see the reverse: "shoulder instability is inversely related to the amount of hard throwing you do". So it seems that throwing is associated with some 'protection' from anterior dislocation rather than an increase in the amount of anterior translation. This could easily be a self-selection problem, i.e. only those that will never dislocate their shoulder end up playing high level throwing sports. So now it is worthwhile seeing what happens to a shoulder when it is placed in this "at risk" abducted and externally rotated position. Research examining the kinematics of the glenohumeral joint suggests that during this movement it is normal for the head of the humerus to translate postero-superiorly[6], not anteriorly.

It is suggested that one adaptation associated with repeated forceful throwing is a tendency for thickening of the posterior inferior band of the glenohumeral ligament[7]. A smaller and contested body of research suggests that the addition of an aberrantly thickened posterior inferior band of the glenohumeral ligament would be associated with an exaggeration of this translation[7]. Examination of the injury patterns commonly incurred in professional throwing athletes reveals higher incidences of superior labral injury[7] and undersurface tears of the postero-superior rotator cuff[7,8]. It is tempting to therefore suggest that repeated throwing is associated with abnormal translation of the humeral head, but rather than this abnormal translation being anterior and inferior, it is in fact in the exact opposite direction: posterior and superior. This would explain the reduction in incidence of true anterior instability in this group, as well as suggesting a mechanism for the pathology seen: direct mechanical irritation of the undersurface of the cuff tendons postero-superiorly[8] and

tensile failure of the biceps anchor at the superior labrum.

LABRAL INJURIES ARE NOT WHAT YOU THINK

Perhaps

Since the initial description of four sub-types of superior labral injury in the throwing athlete[9], this diagnosis has gained increasing prominence in the literature and now in excess of 12 discrete sub-types of these Superior Labrum Anterior to Posterior (SLAP) lesions are described[10]. Initially, perhaps in part because of the difficulty in successfully managing throwing-related shoulder injuries, there was great hope that SLAP lesions represented the pathology that we had all been missing all along and that identifying and then treating these would be the key to solving this puzzle. However there have been a few potholes along the way. In short, identifying these lesions has proven difficult for a number of reasons. Initially, physical examination alone looked promising (See references 11 and 12, for example). However, every paper which has attempted to verify these findings has come up short[13]. The addition of the subjective features of reported 'clicking/catching' inside the shoulder improves the accuracy[14], as does a history of being a throwing athlete. But all these things together still do not add up to enough evidence for us to be able to definitively diagnose the presence of a SLAP by a combination of history and physical examination. One step up from this is to use imaging and here the only imaging of any use appears to be MRI[15]. The use of MRI, perhaps with the addition of a contrast agent, appeared to be a strong candidate for identifying these lesions. However, the issue has been confounded somewhat by the extremely high likelihood of 'positive MRI' findings in asymptomatic subjects (79% of 28 asymptomatic shoulders)[16].

The perceived 'gold standard' for identifying these lesions then has to be direct identification through surgical inspection. Unfortunately, there have again been issues because what appears to be pathology can instead be entirely normal anatomy[17]. The final complication is found in the fact that the glenoid labrum is, at best, sparsely innervated[18]. The anatomy here is far from being comprehensively documented. Vangsness et al[18] had only this to say about innervation in their depiction of the anatomy of the labrum:

"Free nerve endings were noted in the surrounding connective tissue. Occasional free nerve endings were noted in the fibro-cartilage tissue of the labrum and these appeared only in the peripheral half."

And that is the extent of our understanding of the innervation of the labrum.

Currently, it appears that the labrum certainly can be implicated in pain and dysfunction of throwing athletes, but finding out who these athletes are is much trickier than we first thought. Once identified, the management is also currently up for debate with advocates for debridement, stabilisation, tenodesis of the long head of the biceps and also conservative care. Current opinion suggests roughly equivocal results for conservative care and debridement and worse results when SLAP repair and rotator cuff surgery are required[19].

My opinion (and this will certainly change as time passes and we learn more about this), is that conservative care needs to be tried first for the thrower with a proven SLAP lesion, but if it's going to be successful, you will know this within 4 to 6 weeks. Continued disability and pain in spite of appropriate conservative care attempts are likely to need surgical intervention and the key now seems to be finding the 'Goldilocks' of stabilisation of the biceps anchor whereby the labrum is reattached firmly enough to confer stability to the long head of the biceps but not so firmly as to interfere with the normal movement required during the repeated full range shoulder rotation of throwing.

SPEAKING OF ROTATIONAL RANGE OF MOTION

Assessment of rotational range of motion in the throwing athlete is key in examination, prognosis and directing therapy. Unfortunately it seems that this area has been clouded by a series of acronyms which have only served to confuse the issue. Clinicians need to examine the total rotational range of motion for a throwing athlete in both arms. A healthy thrower will have more or less equal total rotational range of motion in each arm, which is the sum of their internal and external rotational range of motion. The actual number varies quite a bit between individuals. In my experience this has been as low as 150° up to a maximum of 270°. While it is typically in the order of about 180° to 200°, the variability is so great that this "average" number becomes clinically meaningless. However when an athlete presents with a difference from side to side, this becomes clinically meaningful at maybe 10° and almost certainly at 20°[7]. Accordingly, the measurement technique needs to be careful and systematic as the error induced by a casual approach here will certainly mask any important findings that would otherwise be apparent.

If a difference in total rotational range of motion is found, one of our treatment goals immediately becomes restoring this. By far, the most common difference found in throwers is a reduction in total rotational range on the symptomatic side. This is where things become problematic as expert throwers nearly always have their rotational range of motion 'shifted' toward external rotation by virtue of an acquired[20] or congenital[20,21] variation in the amount of twist about the long axis of the humerus. Typically this means they will have more external rotation at the expense of internal rotation and this averages 12°[22]. However, the variability here is again so large as to render this number clinically useless. In one series of 200 athletes the between subject variability was 74° and the maximum within subject variability was 46°[22]. Accordingly, for an accurate idea of which direction range of motion needs to be increased and by how much, some measure of humeral torsion on each side needs to be performed. X-ray[23], CT and MRI methods are described, but in practice, using ultrasound is usually the quickest and perhaps most accurate measure[24], although some training and equipment is still required. Once you know the side to side difference in humeral torsion, it is a simple matter to factor this into your thinking without resorting to 'GIRD' (glenohumeral internal rotational range of motion deficit) or 'ERG' (external rotation gain). If the athlete has, for instance, 20° more humeral retrotorsion on his dominant arm, then he should have 20° more external rotation and 20° less internal rotation on his dominant arm. In truth, it is that simple.

STRENGTH IN NUMBERS

The final suggestion here is that measuring shoulder rotational strength is a useful thing to do in shoulder pain patients generally, but particularly so for throwing athletes. Many different methods are described, ranging from simple, inaccurate and meaningless manual muscle tests up to complex, time-consuming isokinetic dynamometry. In practice, the standardised use of handheld dynamometers has proven to be reliable, valid and clinically applicable. The documentation of both the absolute strengths of internal and external rotation as well as the ratio between these two and the comparison with the non-throwing arm all have clinical use[2]. This technique appears simple (which it is) however, it still requires some training and practice on the part of both the therapist and the patient to gain reliability and validity. I suggest that therapists need to do approximately 20 tests before they can really trust their figures and that most patients can only be trusted from their second session onwards. It seems that despite reassurance, the patients are still wary of pushing maximally during their first visit and you only really see their true strength when they return uninjured for their second visit.

Measuring these strengths allows you to document deficits and therefore accurately plan a rehabilitation regime, as well as infer the magnitude of the work to be done. During rehabilitation you can then continue to monitor these strengths to ensure that any programme you've administered is heading in the right direction and fine-tune things when they are not. Equally important is when restoring a demonstrated strength deficit and the thrower is not improving clinically. This is a sure sign some other pathology for this individual has been missed which is causing their problem and it is time to reassess them.

Pre-season assessment of these strengths also is demonstrated to be predictive of the likelihood of injury requiring time out of throwing[25] and need for surgery in a population of professional baseball players. It stands to reason that pro-actively addressing identified strength deficits would be a route to reducing the injury burden associated with throwing. However, at this stage we only have preliminary unpublished data for this. A Scientific Meeting held as part of the 2015 Handball World Cup in Qatar should reveal more.

Clearly there is still much for us to learn in regards to throwing – an activity that we've been likely doing for many millenniums. Right now, though, I'm off to watch a game of handball.

> *"conservative care needs to be tried first for the thrower with a proven SLAP lesion, but you will know if this is going to work within 4 to 6 weeks"*

THROWING IS THE MOST IMPORTANT THING HUMANS HAVE EVER DONE

Throwing is the smart way to hunt and police

Humans are reported to perform two unique hunting methods both of which lay claim to setting us apart on a more successful evolutionary path. Hunting at a distance by throwing (rather than fighting animals up close, with clubs, as the Neanderthals did[26]) allows you to walk away from an unsuccessful hunt unscathed and at very little energy cost in comparison to the other method: persistence hunting (running an animal to exhaustion at a speed too high for it to adequately thermoregulate via panting[27,28,29]).

In a societal context, the ability to enforce tribal mores through coalitional 'ganging up' and stoning into submission (or death) unruly members allowed for more successful societies unhindered by these physically dominant bullies[27]. No longer would the physically largest member be assured of group dominance. Imagine the surprise of the first tribe that was confronted by a group of throwers who could inflict damage and even death from shouting distance.

Throwing gave us bigger brains

There's also the suggestion that the development of the ability to accurately and forcefully throw was a precursor (and pre-requisite) to human language[30,31]. The required increase in brain size to allow accurately timed throws (hitting a target the size of a rabbit from a distance of two car lengths requires a release window of about 1/2000th of a second) forced an expansion in brain size in a region that was later co-opted for language (in the contralateral hemisphere[3]). Throwing came first, it's suggested, as the ability to hunt and therefore feed in a plain devoid of nuts but full of rabbits was more important than the slower survival advantage that language (and therefore hunting and defending in a planned and co-ordinated manner as a pack) would confer.

You have no idea how devastating throwing stones can be

Early historic accounts[32] vividly portray the deadly force that stone throwing imparts against 'better armed' and more 'modern' adversaries.

In the Middle Ages, the crossbow was the 'nuclear weapon' of its time. In 1139 Pope Innocent II condemned it as "deathly and hateful to God and unfit to be used among Christians."

All the same it proved no match for skilled stone throwers: "It happened that when the cross-bow men shot their bolts they did little harm, for the Guanches never remained in one place, but kept moving about, so that it was difficult to take sure aim ... They hurled stones with much more effect breaking a shield in pieces and the arm behind it"

Breaking a shield in pieces, "and the arm behind it". Consider that for a moment.

A few hundred years later and Canary Islanders are recorded as decimating a 15th century Portuguese landing party: "In hardly any time at all they had so badly beaten us that they had driven us back into shelter with heads bloodied, arms and legs broken by blows from stones: because they know of no other weaponry and believe me that they throw and wield a stone considerably more skilfully than a Christian; it seems like the bolt of a crossbow when they throw it"

Similarly a group of 18th century explorers met a sticky end (12 of the 61 were killed and many others injured) when attempting to engage some south sea islanders: "... the enormous stones hurled by the savages maimed one or other of our people at every moment and whenever a wounded man fell into the water on the side of the savages, he was immediately despatched with clubs and paddles" and "... a shower of stones, so much the more difficult to avoid, as being thrown with uncommon force and address, they produced almost the same effect as our bullets and had the advantage of succeeding one another with greater rapidity"

Australian aboriginals are documented as being especially dangerous to the better-armed 18th and 19th century colonial invaders: "Many a time, before the character of the natives was known, has an armed soldier been killed by a totally unarmed Australian. The man has fired at the native, who, by dodging about has prevented the enemy from taking correct aim and then has been simply cut to pieces by a shower of stones, picked up and hurled with a force and precision that must be seen to be believed ... To fling one stone with perfect precision is not so easy a matter as it seems, but the Australian will hurl one after the other with such rapidity that they seem to be poured from some machine; and as he throws them he leaps from side to side so as to make the missiles converge from different directions upon the unfortunate object of his aim."

You are probably right-handed because of throwing

Humans are largely right-handed, as opposed to all the other apes who are equally likely to be left- or right-handed, since there was a small survival advantage conferred on the mother who could keep her baby quiet holding it in her left arm where it is sedated by the sound of her beating heart, thereby allowing her to hunt (or defend herself) by throwing with her free right hand[28].

References

1. *Jobe FW, Kvitne RS, Giangarra CE. Shoulder pain in the overhand or throwing athlete. The relationship of anterior instability and rotator cuff impingement. Orthop Rev 1989; 18:963-975.*
2. *Whiteley R, Oceguera MV, Valencia EB, Mitchell T. Adaptations at the shoulder of the throwing athlete and implications for the clinician. Techniques in Shoulder & Elbow Surgery 2012; 13:36-44.*
3. *Hovelius L. Incidence of shoulder dislocation in Sweden. Clin Orthop Relat Res 1982; 127-131.*
4. *Edelson JG. Bony changes of the glenoid as a consequence of shoulder instability. J Shoulder Elbow Surg 1996; 5:293-298.*
5. *Orchard J, James T, Alcott E, Carter S, Farhart P. Injuries in Australian cricket at first class level 1995/1996 to 2000/2001. Br J Sports Med 2002; 36:270-274.*
6. *Chhadia AM, Goldberg BA, Hutchinson MR. Abnormal translation in SLAP lesions on magnetic resonance imaging abducted externally rotated view. Arthroscopy 2010; 26:19-25.*
7. *Burkhart SS, Morgan CD, Kibler WB. The disabled throwing shoulder: spectrum of pathology part I: pathoanatomy and biomechanics. Arthroscopy 2003; 19:404-420.*
8. *Borsa PA, Laudner KG, Sauers EL. Mobility and stability adaptations in the shoulder of the overhead athlete: a theoretical and evidence-based perspective. Sports Med 2008; 38:17-36.*
9. *Snyder SJ, Karzel RP, Del Pizzo W, Ferkel RD, Friedman MJ. SLAP lesions of the shoulder. Arthroscopy 1990; 6:274-279.*
10. *Mohana-Borges AV, Chung CB, Resnick D. Superior labral anteroposterior tear: classification and diagnosis on MRI and MR arthrography. AJR Am J Roentgenol 2003; 181:1449-1462.*
11. *Liu SH, Henry MH, Nuccion SL. A prospective evaluation of a new physical examination in predicting glenoid labral tears. Am J Sports Med 1996; 24:721-725.*
12. *O'Brien SJ, Pagnani MJ, Fealy S, McGlynn SR, Wilson JB. The active compression test: a new and effective test for diagnosing labral tears and acromioclavicular joint abnormality. Am J Sports Med 1998; 26:610-613.*
13. *Hegedus EJ, Goode A, Campbell S, Morin A, Tamaddoni M, Moorman CT 3rd et al. Physical examination tests of the shoulder: a systematic review with meta-analysis of individual tests. Br J Sports Med 2008; 42:80-92.*
14. *Walsworth MK, Doukas WC, Murphy KP, Mielcarek BJ, Michener LA. Reliability and diagnostic accuracy of history and physical examination for diagnosing glenoid labral tears. Am J Sports Med 2008; 36:162-168.*
15. *Connell DA, Potter HG, Wickiewicz TL, Altchek DW, Warren RF. Noncontrast magnetic resonance imaging of superior labral lesions. 102 cases confirmed at arthroscopic surgery. Am J Sports Med 1999; 27:208-213.*
16. *Miniaci A, Mascia AT, Salonen DC, Becker EJ. Magnetic resonance imaging of the shoulder in asymptomatic professional baseball pitchers. Am J Sports Med 2002; 30:66-73.*
17. *Huber WP, Putz RV. Periarticular fiber system of the shoulder joint. Arthroscopy 1997; 13:680-691.*
18. *Vangsness CT Jr, Ennis M, Taylor JG, Atkinson R. Neural anatomy of the glenohumeral ligaments, labrum and subacromial bursa. Arthroscopy 1995; 11:180-184.*
19. *Kibler WB, Kuhn JE, Wilk K, Sciascia A, Moore S, Laudner K et al. The disabled throwing shoulder: spectrum of pathology-10-year update. Arthroscopy 2013; 29:141-161.*
20. *Whiteley R, Adams R, Ginn K, Nicholson L. Playing level achieved, throwing history and humeral torsion in Masters baseball players. J Sports Sci 2010; 28:1223-1232.*
21. *Whiteley RJ, Adams RD, Nicholson LL, Ginn KA. Reduced humeral torsion predicts throwing-related injury in adolescent baseballers. J Sci Med Sport 2010; 13:392-396.*
22. *Whiteley RJ, Ginn KA, Nicholson LL, Adams RD. Sports participation and humeral torsion. J Orthop Sports Phys Ther 2009; 39:256-263.*
23. *Pieper HG. Humeral torsion in the throwing arm of handball players. Am J Sports Med 1998; 26:247-253.*
24. *Whiteley R, Ginn K, Nicholson L, Adams R. Indirect ultrasound measurement of humeral torsion in adolescent baseball players and non-athletic adults: reliability and significance. J Sci Med Sport 2006; 9:310-318.*
25. *Byram IR, Bushnell BD, Dugger K, Charron K, Harrell FE Jr, Noonan TJ. Preseason shoulder strength measurements in professional baseball pitchers: identifying players at risk for injury. Am J Sports Med 2010; 38:1375-1382.*
26. *McKie R. Dawn of man: the story of human evolution. Dorling Kindersley Pub New York, 2000.*
27. *Bingham PM. Human uniqueness: a general theory. Quarterly Review of Biology 1999; 74:133-169.*
28. *Bramble DM, Lieberman DE. Endurance running and the evolution of Homo. Nature 2004; 432:345-352.*
29. *Lieberman DE, Bramble DM. The evolution of marathon running: capabilities in humans. Sports Med 2007; 37:288-290.*
30. *Calvin WH. The throwing madonna: essays on the brain. New York: McGraw-Hill; 1983.*
31. *Darlington PJ Jr. Group selection, altruism, reinforcement and throwing in human evolution. Proceedings of the National Academy of Sciences of the United States of America 1975; 72:3748-3752.*
32. *Isaac B. Throwing and human evolution. African Archaeological Review 1987; 5:3-17.*

Rodney Whiteley Ph.D.

Research and Education Physiotherapist

Aspetar – Qatar Orthopaedic and Sports Medicine Hospital

Doha, Qatar

Contact: rodney.whiteley@aspetar.com