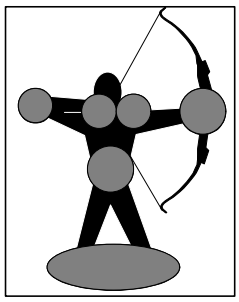


Elements of Form
The Bow Arm

Steve Ellison

AIM:

After the session you should:

- Be able to state a suitable objective of best practice for bow arm use
- Be able to describe the anatomical and mechanical advantages of particular implementations
- Be able to prescribe a performance development programme to achieve best use of the bow arm.

OUTLINE:

Introduction	Talk	5 min
Objectives for the bow arm	Exercise	10 min
Anatomical foundation	Presentation, exercise & discussion	20 min
Mechanical principles	Presentation, exercise & discussion	20 min
Top archers and ideal form	Group exercise/discussion	15 min
Developing best form	Group exercise	15 min
Closing discussion	Discussion	10 min
Post session		
Homework		

Elements of form 1: The Bow Arm

Exercises

Exercise 1: Objective

Write a short statement of the objectives of good Bow Arm use.

Exercise 2: Anatomical foundations

i) Sketch the main bones of the bow shoulder and arm at full draw, as seen from the back.

ii) Add to your diagram the main muscles involved in lifting and supporting the bow and shoulder.

Exercise 3: Forces

Sketch an archer's bow arm at full draw, seen from a) the front and b) the top. In each diagram, draw arrows showing the main forces involved. Try to make the direction reasonably accurate and the length of the arrow roughly proportional to the size of the force (big force=longer arrow).

a) Front view

b) Top view

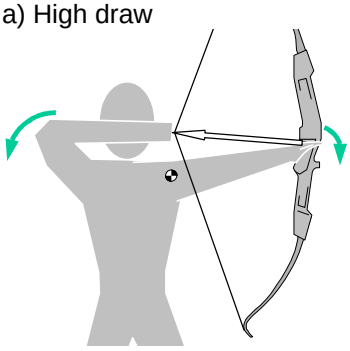
Exercise 4: Efficiency

Given the forces and muscles involved, what arrangement (or arrangements) of the bow arm and shoulder minimise the muscular forces involved? (Hint: A critical point is where the draw force line is in relation to the shoulder joint)

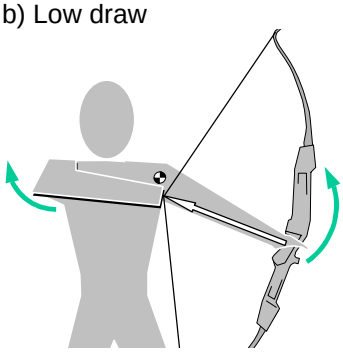
Exercise 5: Drawing the bow

Write down the mechanical and other advantages and disadvantages of the following three draw styles.

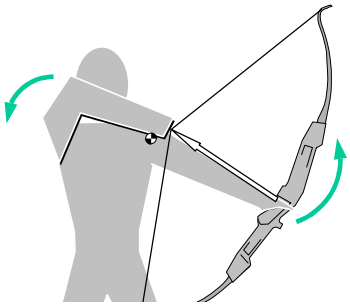
a) High draw



b) Low draw



c) Hybrid



Exercise 6: Analysing technique

i) Follow through

Considering the forces identified in exercise 3, what is the likely bow arm movement (if any) on loosing? (Hint: Which forces disappear? Which remain?)

ii) Top archers' form

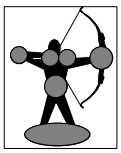
Examine and discuss the available material on top archers.

a) Are there consistent features of bow arm use, and if so, what are they?

b) In general, do top archers appear to follow the 'best efficiency' arrangement identified in Exercise 4?

Exercise 7: Developing technique

Briefly identify the main physical requirements for executing "best" bow arm technique.



Elements of form: The Bow Arm

Notes

1 Objective

The bow arm provides much of the direction for the shot, and takes the force of the draw and the mass of the bow.

Objectives should include

- Safe use, with particular attention to prevention of chronic injury
- Efficient use of muscles (usually corresponding to minimal use)
- Stability
- Excellent fine control of position

2 Anatomical foundation

2.1 Bone structure

The bone structure of the bow arm and hand are shown in Figure 1 (from reference 1).

Important features are:

- The complex bone structure in the hand and wrist
- The radius and ulna, attached to the lower end of the humerus. The bones are independently jointed and allow rotation between elbow and wrist at the cost of changes in alignment along the arm.
- The humerus, a single large bone. The upper end is located in the shoulder joint via a relatively loose ball and socket joint (the glenoid cavity). The range of movement is considerable. Because the head of the humerus does not fit exactly in the glenoid cavity, however, there is some scope for lateral movement in the joint. Upward movement of the arm is limited by contact between the humerus and the top of the scapula (acromial process).
- The shoulder blade, or scapula. Attached to the skeleton only by the clavicle, the scapula can slides across the back, rotate and slide up or down within its range of movement. It is held in place primarily by muscle action.
- The collar-bone, or clavicle. The outward tip of the clavicle supports the scapula. The inner end is fixed to the upper part of the rib cage. Range of movement is moderate, but allows substantial vertical movement. The clavicle varies considerably in shape between individuals, and may be almost straight or substantially bowed.

Given the arrangement of scapula, clavicle and humerus, it is not at all easy to align all three shoulder bones exactly to counter a force acting along the arm and into the shoulder. Muscle action is accordingly essential to control and support the shoulder and upper arm.

2.1 a) Implications for good practice:

(se also mechanical considerations)

- The glenoid cavity allows some freedom of movement; care in the pre-draw and control of draw will be necessary to ensure consistent seating of the humerus in the shoulder joint.
- Because the scapula is stabilised by upper body and shoulder muscle action, appropriate consistent back muscle action is an essential part of good bow arm form

2.2 Musculature

The most important muscles are those around the shoulder joint and upper back. In particular

- The deltoid, attached to the humerus, scapula and clavicle. Primarily lifts the arm; it also assists in pulling the arm to the rear or to the front when extended.
- Trapezius and rhomboids; upper back muscles, primarily useful in inward movement of the shoulder blade.
- Rotator cuff musculature. A collection of muscles important in rotating the upper arm and in controlling and supporting the humerus in the shoulder joint.

Other important muscles include

- The serratus anterior, which pull the scapula outward and forward (the only direct 'push' for the bow arm)
- The biceps, triceps, and brachial, largely responsible for bending and straightening the elbow. The triceps in particular may be needed to keep the bow arm extended, especially with the elbow either part flexed or oriented outward.
- Supinator and pronator groups, chiefly deep muscles located near the elbow joint, rotate the wrist.
- Wrist extensor and flexor groups in the forearm extend and flex the hand at the wrist.
- Muscles of the thumb: about eight muscles controlling the thumb, particularly those controlling inward movement.

During the draw and shot, the main active muscle is the deltoid. However, nearly all the muscles in and around the shoulder are needed to control the movement and stabilise the joint. Lower arm and wrist muscles may also stabilise the elbow joint and wrist, but the forces required are small unless a high wrist position is used, when the wrist joint needs additional stabilisation. Off-centre pressure on the palm of the hand would also need opposition either from wrist extensors or from muscles at the base of the thumb.

Many of these muscles, particularly back muscles, are little used in daily life, so some conditioning , or at least, bow weight progression, is essential in early archers. Peak strength and endurance under tournament conditions will also normally require specific conditioning.

2.2 a) Implications for good practice:

- Muscles in and around the bow shoulder joint and upper back are critically important and will need specific conditioning for peak performance.
- The upper and posterior deltoid, rhomboids and trapezius are heavily loaded and require most conditioning. The serratus anterior may need exercise too if a 'push' action is desired.
- Rotator cuff development is indicated for fine control and for injury prevention (below).

Note: Normal training principles apply. General toning is probably adequate for most club archers; for top athletes, more specific training – matching the loading pattern and timing in archery - is suggested. Note that shooting does itself provide a degree of specific conditioning, but overload is required for progression.

2.3 Safety and injury

Probably the most common bow arm injury is string injury to the bow forearm, particularly in beginners. The usual temporary remedy is to adopt a slight bend in the bow arm. This becomes impractical with a tournament weight bow; recommended practice is to learn appropriate outward rotation of the elbow (achieved by rotation from the shoulder rather than the wrist). Note: a former GNAS medical adviser noted that though rarely serious in archery, severe bruising can result in clotting and later obstruction of critical blood vessels, including lung and heart. It is actively dangerous, as well as painful, to permit continued string injury.

Otherwise, there seems to be no strong clinical evidence of specific bow arm injuries in archery (Ref. 2). The most vulnerable joint is the shoulder. Improper use – particularly over-reliance on undeveloped muscles - can lead to muscle strain and, perhaps more seriously in the long term, damage to the joints and tendons. Injury is best avoided by balanced muscle loading (i.e. spreading the load) and alignment of the arm and shoulder bones to minimise muscle use. Fortunately, this is consistent with best efficiency.

Note, too, that while the movement range is not as great as in the drawing arm and shoulder, flexibility is important to avoid strains. Warm-up is also, as usual, a sensible precaution.

The compressive forces on the bow arm generate **bone end loadings**; particularly in younger archers, bone end loading is implicated in permanent deformity in the growing bones. This is important at all joints, but (in the early to mid 80's) there was some evidence of particular damage to the shoulder joint around the acromion (the outer tip of the shoulder blade, on top of the shoulder).

Other (anecdotal) problems include stress-related injury in the elbow joint, sometimes ascribed to 'shock' with fast bows and light arrows, or possibly due to abrupt straightening of the elbow joint with over-extension. Some archers have reported relief after fitting vibration damping equipment. I am also aware of one archer who suffered multiple compressive fractures in the shoulder joint through attempting to draw an over-heavy longbow, eventually requiring surgical treatment.

Implications for good practice:

- Outward rotation of the elbow is safer and offers more support for the bow forces than bending the arm
- Bones should be more or less aligned to reduce lateral strain on joints and supporting muscles
- Mann (reference 1) recommends including rotator cuff conditioning (toning only) in training programmes to reduce chances of rotator cuff injury.

3 Mechanical principles

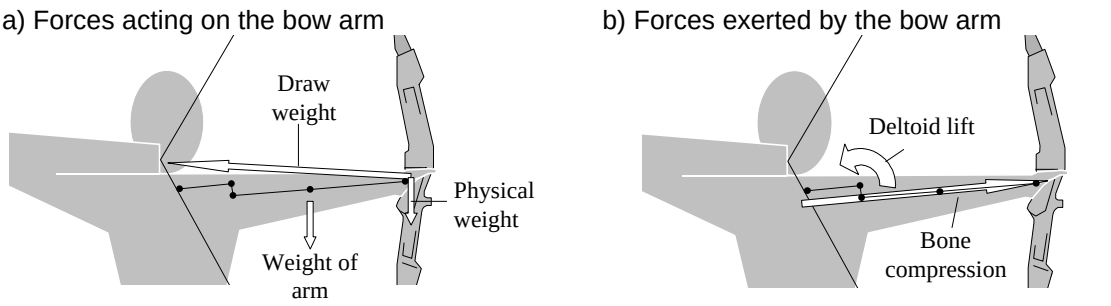
3.1 Main Forces

3.1 a) Vertical forces.

Figure 2 shows the main vertical forces on the bow arm at full draw. These are:

- The weight of the bow and bow arm (force due to gravity)
- The vertical component of the draw weight, ultimately originating with the draw force from the drawing arm.
- The vertical component of the bow arm's forward pressure. That force largely originates in the reaction to bone and joint compression, with shoulder muscle assistance.
- The lift generated chiefly by the deltoid in the first instance.

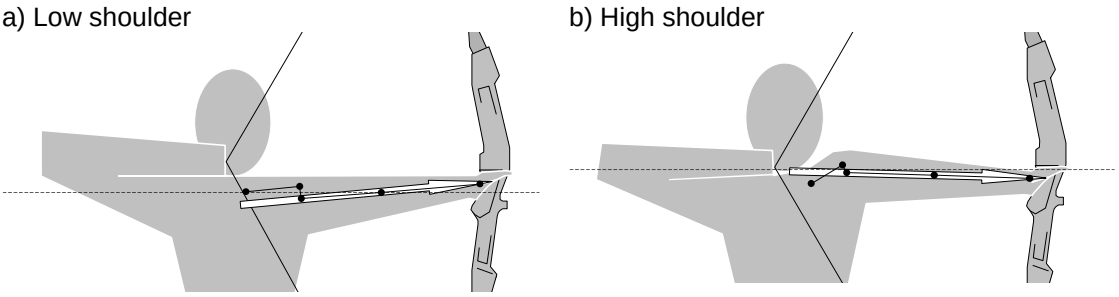
Figure 2: Main forces at full draw: Front view



For a stationary bow, the forces in figure 2 balance. Notice in Figure 3 that for a low shoulder (shown) relative to the draw-force line (shown as the draw weight force line), the *forward* pressure of the front arm on the bow helps to *lift* the bow. For a very high shoulder, the reverse is true. (The dashed lines in figure 3 are horizontal, for reference). In general, the lower the bow shoulder, the less lift is required from the deltoid.

In principle, a high enough draw/force line can reduce the lift required to zero. In practice, for a typical recurve or compound bow, the reference point would need to be more than about 5" above the shoulder joint; just feasible for compound and field shooters, but essentially unattainable for most target recurves. Deltoid use is accordingly almost universal.

Figure 3: High and Low shoulder positions



3.1 b) Horizontal forces

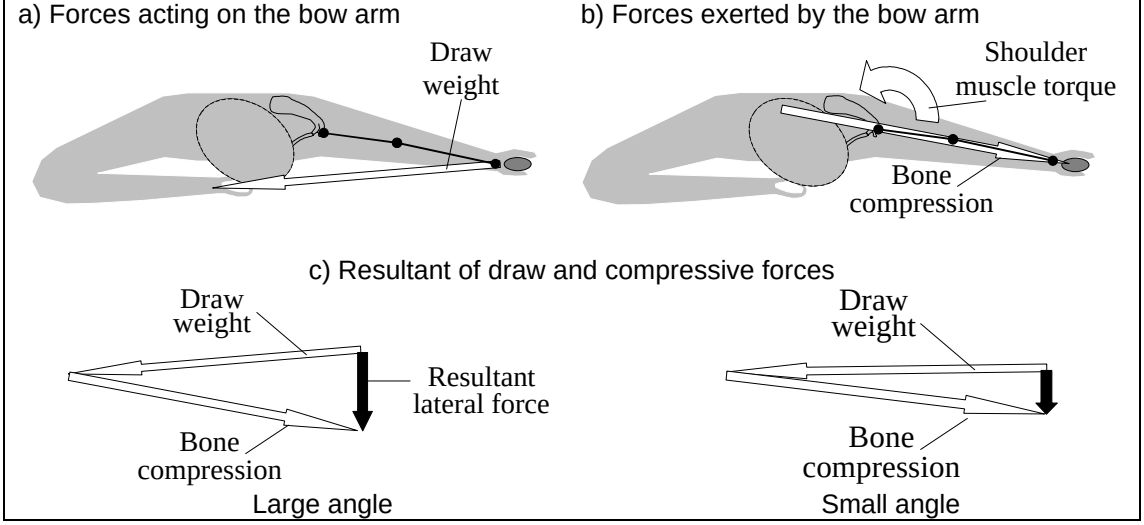
The horizontal forces are shown in the top view in Figure 4 .

The main horizontal forces are

- The horizontal component of the draw weight, acting at the bow hand in the direction of the draw force.
- The horizontal component of the bow arm's forward pressure, again acting at the bow hand.
- A lateral force generated at the shoulder (and again, transferred via the scapula to the spine)

The most important feature is that, while the first two balance almost automatically in the shooting plane, the resultant is a force in the sagittal direction. (Figure 4c). This must be balanced by a lateral force generated at the shoulder and transmitted to the grip. Since this force is greater for large bow arm/draw line angles, the smaller this angle becomes, the less lateral force is needed from the shoulder.

Figure 4: Main forces at full draw: Top view



3.1 c) Muscles and forces

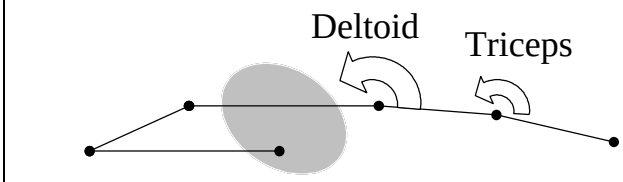
It is worth considering which muscles are needed to generate the bow arm forces involved in holding the bow, and how they are transmitted.

The *vertical lift* is generated mainly by the deltoid contracting towards the clavicle and scapula. The scapula is in turn held in place mainly by the upper and central trapezius; the clavicle by its association with the scapula, assisted (possibly) by the subclavial muscle.

The *lateral force* exerted by the deltoid (among others) is transmitted to the spine in part by the trapezius, but in this case, the rhomboid is also important in holding the scapula in place.

The lateral force from the shoulder is transmitted to the bow via the elbow. Typical recommendations place the elbow outward; in principle, the arm can then flex inward. To keep the elbow straight the triceps *have* to be in play (Figure 5).

Figure 5: Function of triceps (elbow outward)



Implications for best practice

- Minimising the bow arm/draw force line angle (closing the stance) minimises superfluous muscle use
- A front shoulder below the draw-force line reduces strain on the upper deltoid

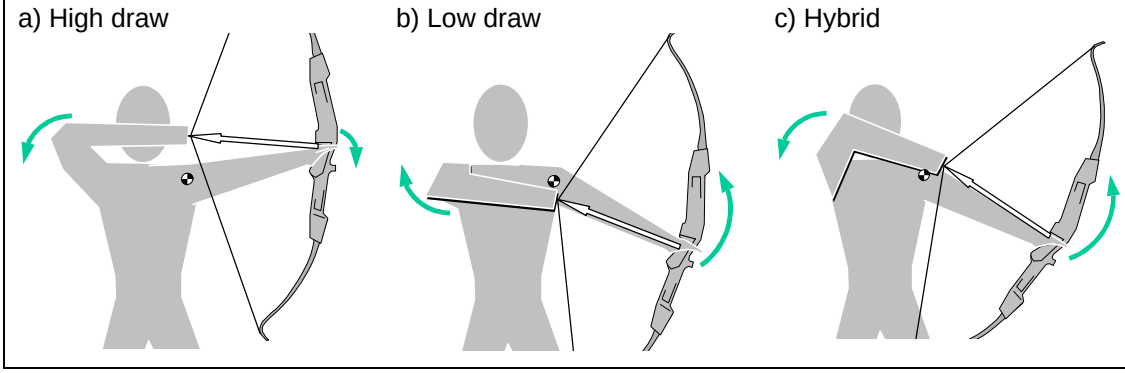
3.2 Dynamics

3.2 a) Achieving full draw

The aim is generally to achieve a consistently seated shoulder, with well aligned arm and shoulder bones to minimise excess muscle use.

There are broadly two draw styles, distinguished by the position of the draw/force line during the draw. A low draw places the line low, applies pressure and comes up to aim; a high draw (relative to the shoulder joint) brings the bow up and then applies a draw force. An interesting hybrid technique keeps the draw line “above” the shoulder whilst lifting the bow. The three are shown in Figure 6, which also shows the approximate position of the shoulder joint.

Figure 6: Three draw styles



Of the three styles:

a) High draw

Advantages: Leads to minimal movement, starts most aligned, places least strain on the deltoid during the draw, and takes best advantage of the arrangement of shoulder bones and muscles. The bow arm angle tends to keep the shoulder down and stable during the draw. Also, as the draw weight increases during the draw, the draw/force line /bow arm angle closes, so the non-muscular vertical forces are most nearly balanced throughout the draw.

Disadvantages: Moderately large rotational movement in the drawing arm, which starts in a rather awkward position unless a significant pre-draw is used (as shown). Possible interference between drawing arm and head during the draw. Large upper body movement likely unless executed from a pre-draw position with shoulders already in or near the final line.

b) Low draw

Advantages: Apparently simple single movement ("v-draw"). Symmetrical use of upper back muscles to lift arms.

Disadvantages: Shoulder forced out of final 'best' line by low initial DFL (the arm is pushing the shoulder upward for most of the draw). Deltoid has to overcome low DFL as well as raising bow mass. Bow shoulder has to make large movements under increasing strain. Large movements in both arms make consistency hard to achieve. A disaster all round!

c) Hybrid draw

Advantages: Mechanically similar to a) for deltoid.

Disadvantages: Shoulder again pushed upward during draw (more extreme than b)). Extreme drawing shoulder movement and large bow shoulder movement while under considerable stress. An injury waiting to happen, as well as difficult to achieve consistently!

Implications for best practice

- A T draw, slightly above the shoulder, is safer, mechanically efficient and involves minimal variation, especially if a pre-draw is used to settle the body in position first.

3.2 b) Aiming

During aiming, the bow is balanced primarily by static forces. The most important dynamic considerations relate to control of unwanted movement; wind-induced or simple muscle tremor.

The most important elements are rapid and effective response to unwanted movement. This is best achieved by muscles under minimum load, but (because of the actin/myosin linkages in muscle fibre) under light tension, i.e. slightly contracted.

Implications for best practice

- Complete relaxation may be a bad thing
- Efficiency should pay off in aiming control

3.2 c) The shot

Many archers use a clicker, requiring some extension of draw. There is debate as to whether this is best generated from the front arm by forward extension, by the drawing arm via back muscle contraction, or by some combination of the two. For the moment, it is safe to assume that drawing arm movement as a means of extension has no effect on the bow arm, except to say that the bow arm does need to remain stable during the process. However, forward extension is a different matter.

Front arm extension can be achieved by

- Straightening a relaxed elbow or wrist
- Pulling shoulder bones into alignment

- Outward movement of the scapula using the serratus anterior

A common feature is that the movement possible form any of the three is modest; all will work with a closely set clicker and good draw length control; some, especially scapular extension (the third) give very little movement and are unlikely to work well with variable draw length.

Most movements in the bow arm have practical disadvantages:

- Straightening the wrist risks changes in lateral pressure or torque on the bow. It may also lift the pressure point, changing the vertical component of the DFL and bow arm forces and leading to a secondary adjustment in shoulder effort
- Straightening at the elbow assumes first that the elbow is sufficiently bent to allow useful movement, suggesting high use of the triceps. Further, the follow through will tend to take elbow extension into over-extension with potential for injury.
- Pulling the shoulder 'into alignment' often results in moving the shoulder or chest inward (towards the string), with some risk of increased interference.
- Outward movement of the scapula has to occur against the full force of trapezius and rhomboids, which are trying to hold the scapula stable against the bow and deltoid forces.

These disadvantages are often considered to be offset by other factors, however; more relaxed loose, better maintenance of pressure towards the target etc.

Implications for best practice

- If a forward pressure is desired, train the muscles accordingly, paying particular attention to those (antagonists) likely to be subjected to post-shot stretch (see next section also)

3.2 d) Follow through

For the bow arm, the forces at full draw are those shown in figures 2 and 4. As the string is loosed, the draw force (and its countering bone compressive forces) rapidly disappears, leaving most of the muscles still contracted. The expected movements are accordingly;

- The loss of most of the vertical forces holding the bow up (high DFL) result in a tendency to drop the bow. The less the deltoid is in use at full draw, the faster the bow will drop.
- The lateral force from the shoulder should cause the bow to move sideways (left for a right-hander and vice versa). The more out of line the arm, the larger this tendency should be.
- With a bent bow elbow, the joint will straighten abruptly under the force of the triceps.

The sharp drop for a relaxed bow arm may place sudden stress on upper shoulder muscles as they stretch; in extreme cases, this may cause stretch reflex and possible injury. Similarly, abrupt straightening of the elbow joint may cause joint injury.

Practical observation suggests that most of these natural movements are moderate (or possibly suppressed) in better performers. The deltoid is usually taking some strain, so the bow should not drop very rapidly. Lateral forces are minimised in well aligned shoulders.

Implications for best practice

- Very high draw force lines may result in unacceptable bow drop
- Train deltoid and antagonists to cope with post-shot stretch (strength/flexibility conditioning)
- A coaching tip; if the bow doesn't move, either something is holding it there, or the archer has anticipated the shot!

4 Top performers

Most top performers now adopt a T draw from on or just above the aiming point, show a low front shoulder, relatively fully extended front arm and little bow reaction on release. The shoulder varies; McKinney (Ref. 3) tends to recommend a slightly raised shoulder as 'natural' (though the joint is still below the DFL); others may have very low or 9especially in earlier techniques) surprisingly high shoulder positions.

Bow arm action on shot varies with the type of extension used to trigger the shot; some clearly use front arm extension, some back.

One characteristic of most (especially male) archers is good shoulder joint flexibility coupled with extensive muscular development around the shoulder. All are on (for archers) extensive training programmes, typically geared to toning rather than strength development (there are some exceptions). Perhaps more importantly, all shoot high volumes; 300 shafts/day is not unusual in the lead-up to major tournaments; though asymmetric and therefore risking permanent damage, this does constitute a major portion of their sports-specific muscular conditioning.

5 Developing best practice

5.1 Strength and flexibility requirements

Archery places substantial, but rarely extreme, demands on shoulder muscles and joints (compared with gymnastics or parallel bar exercises!). Recommended conditioning for most is 'toning' (moderate to high repetitions with moderate load), coupled with flexibility maintenance (stretches). Strength development may be necessary for major muscle groups, however; the deltoid is particularly heavily used both to lift the bow and apply lateral force and may benefit from specific strength training.

It is important to condition ALL the shoulder muscles; many are invoked post-shot by stretch reflexes or other rapid movements; all are important in stabilisation and fine control. Normal conditioning practice (within sessions) is to warm up, exercise larger muscles first and progress to smaller muscles later.

In general, for developing club archers, shooting alone provides basic conditioning provided that bow weight is increased progressively. However, if flexibility or strength prevent achievement of good alignment and appropriate shoulder positioning, flexibility and/or strength training may be needed to progress. Note, too, that most better archers either use high shooting volume, additional training, or both, to improve condition.

5.2 Skill development

The most important elements of skill development for the bow arm are 'best' alignment and efficient muscle use. Skill development is accordingly likely to;

- Educate the archer on relevant mechanical principles (depending on the archer/coach relationship)
- Move towards a pre-drawn T-draw for simplicity and consistency
- Select a shoulder and arm position and stance which promotes good alignment without string interference
- Stress careful prior positioning of bow hand and shoulder position (vertically and laterally)
- Develop consistent drawing technique through practice.

6 Bibliography

1. Ray Axford, *Archery Anatomy*, Souvenir Press, London (1995). ISBN 0-285-63265-5

2. D L Mann, *Injuries in archery* in *Clinical practice of Sports Injury Prevention and Care*, P. A. F. H. Renström (Ed), Blackwell Scientific, London.

3. R McKinney, *The Simple Art of Winning*

Elements of form: The bow Arm

Post-session Assignment

1 Anatomy and function

i) Sketch the main bones and muscles involved in use of the bow shoulder and arm. Briefly state the function of each of the muscles at full draw.

ii) Briefly discuss the mechanical advantages and disadvantages of

a) a closed stance, with the string close to the body, compared to an open stance.

b) a DFL significantly above the shoulder joint

2 Developing technique

i) Explain how you would train for (ie exercise!) and develop good bow arm technique in a developing archer.

ii) Suggest remedies for the following problems:

a) An archer complains that they cannot hold the bow out straight for a full FITA, and the muscles right at the top and back of their bow arm always seem really stiff a day or so later. (Suggest possible technique changes and possible muscle conditioning exercises)

b) An archer finds it hard to get their shoulder extended straight out, even without the bow, so they are forced to a very open stance with a high shoulder. (Assume that there is no clinical reason and that the archer is otherwise fit)

Session feedback

Session:_____ Name (optional) _____

Date: _____

	Fully	About right	Partly	Miles off
Do you think the session (including homework) met its objectives?	☐	☐	☐	☐

	Far too basic	Basic	About right	Difficult	Oh help!
Difficulty rating;	☐	☐	☐	☐	☐

	Too long	About right	Too rushed
Timing	☐	☐	☐

General Comments

How do you think the session could be improved?

It would be particularly useful to have some indication of specific things that were not well explained, over-discussed, things that you think should have been discussed and were not.