Understanding rib stress fractures and the mechanics behind them

STRIPPED TO THE BONE

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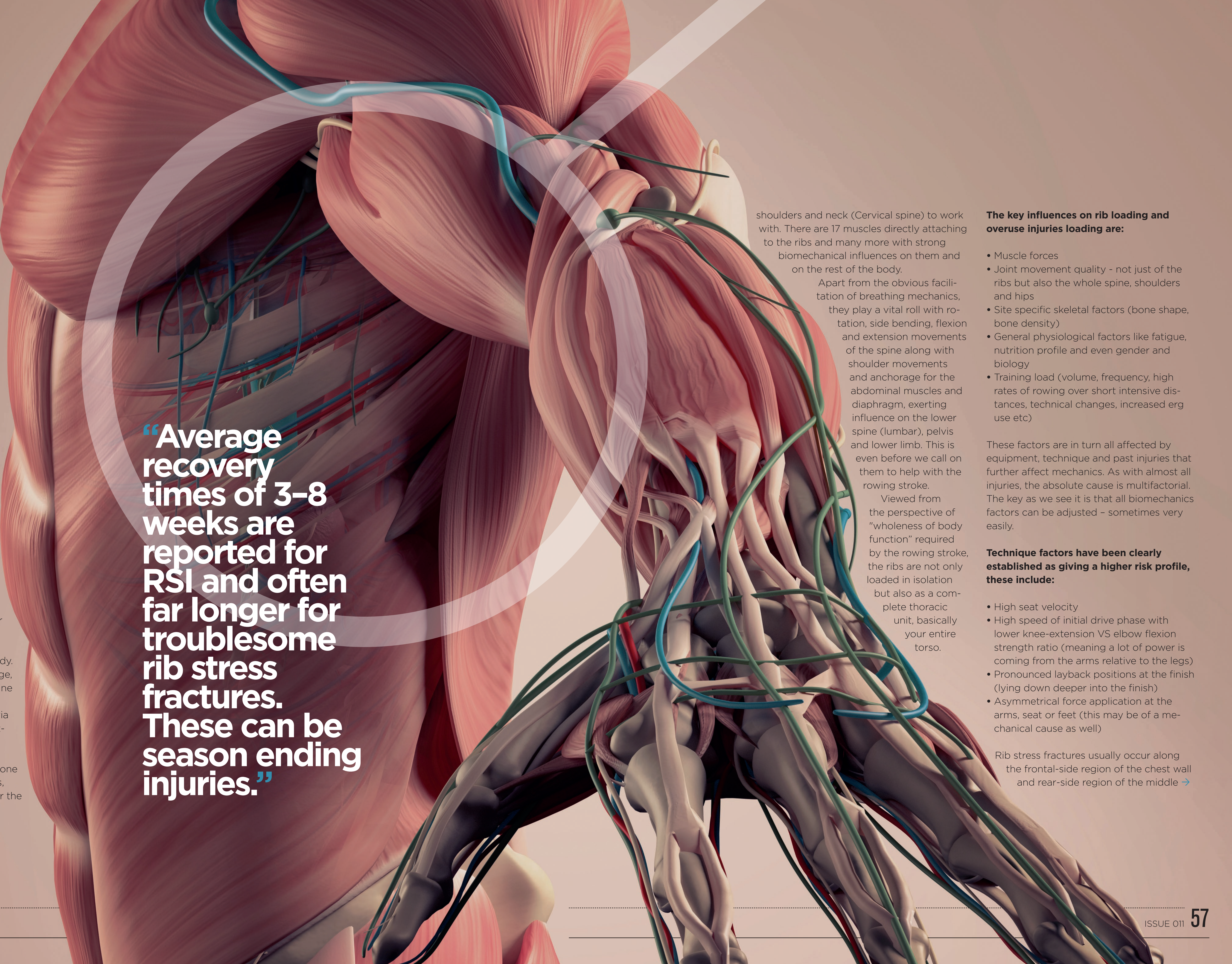
A principle of science and of medicine in particular is that one must understand the normal, or natural status of any studied topic before attempting to describe the abnormal or pathologic. It's an approach we like to apply in every sport we work in. This approach helps to create understanding and accurate diagnosis with a focus on treating the cause/s rather than simply putting bandaids on symptoms.

In rowing all the faculties and structures of the body are needed to deliver performance. All regions must be working well as segments and as a total unit to create the stroke. When one area is dysfunctional, the effects can be disastrous and widespread. The ribs are a great example and one of the most infamous injuries for rowers is the Rib Stress Injury (RSI) and often resultant →



rib stress fracture. RSI and stress fractures are repetitive use injuries that begin with repeated micro trauma to the bone tissue which causes bone oedema and pain (swelling), then can build up in time to reveal small but nevertheless painful and serious fractures in the bones affected or in their protective coating.

Thankfully rib stress fractures are less common than low back or knee injuries, with literature reporting an incidence of 2-12.9% in rowers, making up approximately 10% of all rowing injuries. Once they occur however they cause the most lost time for training and racing of all the overuse injuries. Average recovery times of 3–8 weeks are reported for RSI and often far longer for troublesome rib stress fractures. These can be season ending injuries. When a rib stress reaction is noted, literature shows an average of 47.8 training days lost, this blows out to 60.0+ days lost for complete rib stress fracture. These stats are for elite athletes who have access to top grade medical care and management - in your average club rower these numbers may be far worse.

When looking at the ribs we must consider the load they bear in the body. There are 12 pairs of ribs in the rib cage, attaching at the thoracic (middle) spine at the back and the sternum (breast bone) at the front – some indirectly via cartilage or for the 11th and 12th 'floating ribs' there is no bony or cartilage attachment at the front. The attachments form part of a closed ring of bone surrounding vital organs (heart, lungs, liver etc) and provide a framework for the shoulders and neck (Cervical spine) to work with. There are 17 muscles directly attaching to the ribs and many more with strong biomechanical influences on them and on the rest of the body.

Apart from the obvious facilitation of breathing mechanics, they play a vital roll with rotation, side bending, flexion and extension movements of the spine along with shoulder movements and anchorage for the abdominal muscles and diaphragm, exerting influence on the lower spine (lumbar), pelvis and lower limb. This is even before we call on them to help with the rowing stroke.

Viewed from the perspective of "wholeness of body function" required by the rowing stroke, the ribs are not only loaded in isolation but also as a complete thoracic unit, basically your entire torso.

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The key influences on rib loading and overuse injuries loading are:

- Muscle forces
- Joint movement quality - not just of the ribs but also the whole spine, shoulders and hips
- Site specific skeletal factors (bone shape, bone density)
- General physiological factors like fatigue, nutrition profile and even gender and biology
- Training load (volume, frequency, high rates of rowing over short intensive distances, technical changes, increased erg use etc)

These factors are in turn all affected by equipment, technique and past injuries that further affect mechanics. As with almost all injuries, the absolute cause is multifactorial. The key as we see it is that all biomechanics factors can be adjusted – sometimes very easily.

Technique factors have been clearly established as giving a higher risk profile, these include:

- High seat velocity
- High speed of initial drive phase with lower knee-extension VS elbow flexion strength ratio (meaning a lot of power is coming from the arms relative to the legs)
- Pronounced layback positions at the finish (lying down deeper into the finish)
- Asymmetrical force application at the arms, seat or feet (this may be of a mechanical cause as well)

Rib stress fractures usually occur along the frontal-side region of the chest wall and rear-side region of the middle →

MECHANICAL RISK FACTORS

- Poor trunk strength/endurance
- Poor trunk mobility/flexibility
- Concurrent shoulder pathology/injury
- Low back injury
- Asymmetries of leg length or force production
- Previous rib injury
- Lightweight rowers (metabolic profile)
- Females
- Reduced bone density
- Weight loss/energy deficiency

TRAINING RISK FACTORS

- Rowing or ergo at high load/low rate or overheard
- Rowing against strong wind/current
- Rapid increases in training load/volume/Intensity
- Long steady state rowing
- Change from sweep to sculling and vice versa
- Change from large to small boat
- Rigging overgeared or too much height
- Sudden change to resistance training programs

Ref: Evans G, Redgrave A., Great Britain Rowing Team guideline for diagnosis 2015, BJSMvand management of rib stress injury
McDonnell LK, Hume PA, Nolte V, et al. Rib stress fractures among rowers: definition, epidemiology, mechanisms, risk factors and effectiveness of injury prevention strategies.

torso - around ribs 5-9. These regions are the location for the insertion of the serratus anterior muscle. Most rowers will experience the stress fractures on one side predominantly but they can occur on both sides with repeated injury. Due to the regions of rib injury, the serratus anterior and its relationship with the external oblique muscle, into which it blends, are implicated in almost all cases.

A much less common rib stress fracture occurs on the first rib, the cause of which is repetitive stress from contraction of the anterior scalene muscle (a muscle on the side of the lower neck that helps with breathing and side-bending). It is very similar to stress fractures caused by coughing, although the causative factors listed above will again be very relevant in this case - it's all mechanics.

The Muscles

The muscles implicated in the strain on the ribs tend to be serratus anterior [*A* in the diagram], the external obliques [*B*] and latisimus dorsi (the lats) [*C*]. Although the absolute mechanisms are not always the same for individuals.

The serratus anterior attaches to the outside of the middle ribs under the arm, and the inside edge of the shoulder blade. It holds and rotates the shoulder blade on the chest wall in movements like reaching into the catch and bracing through the arm retraction of the draw.

The external obliques blend into the serratus anterior muscle. They attach to the middle to lower ribs and run into the linea alba, the midline tendon in between the abdominal muscles i.e. the spilt in a six pack for those lucky enough to have them, then attach onto the front of the pelvis. The obliques have a strong attachment and link to all of the core muscles and aid with breathing and flexion and rotation of the trunk.

The latisimus dorsi is a very strong muscle with many roles in stability and strength. It attaches to the lower thoracic spine (middle), thoraco-lumbar fascia, pelvis, ribs 8-12 and inserts into the upper arm like a line of support up from the pelvis to the shoulder. It is used for pulling and lowering of the arm along with a myriad of stabilising roles - including the hang and force transfer from legs to arms in the stroke.

Between these three muscles we have some of the key mechanical stress forces pulling on the ribs during the rowing stroke. Common characteristics of these muscles include the level of influence exerted on them by the lower limb and pelvis and the influence they have on the shoulder (although less pronounced with the obliques).

The Strain

When the drive phase starts, the muscles create force but also contract to stabilise the body, this causes an exponential increase in the tension of the ribs and their muscular influences as the rower braces for the effort of the legs, breathes and prepares to load the arms and swing the spine.

The micro trauma that causes the stress fracture/reaction is caused by excessive and uneven forces, including those applied or transmitted by these three key muscles resulting in asymmetrical/excessive loading of the ligaments and bones of the torso. A great example is the right arm being pulled harder and earlier in the stroke vs the left, when there is a lot of weight on the blade. This creates an uneven distribution of force and the right side of the shoulder carriage, mid spine and ribs will cop the brunt.

Often these mechanical issues present at the rib cage but the cause can be far wider reaching – as you can see the muscles directly involved are affected by many other structures. In the past many of the studies into rib stress fractures have really focused on nutrition, training loads and physiology but we would advocate that the easiest factors to address and those with the most immediate results are related to the rower's mechanics, which dictate force production, force transmition and movement patterns.

The Mechanical Tweaks

Firstly we must understand and acknowledge the individual postural and mechanical deficiencies and differences in the body, those of the spine, pelvis, lower limb, shoulder and ribs directly and then plan pre-emptive solutions around these with the additions of technique and equipment adjustment.

Balancing and increasing the stability of the main force generating movements of the stroke is an important first step and the legs would be a good place to start, as they account for between 55%-70% of the total force produced. Then it is a matter of force transmission up the body - does the athlete have the adequate range of motion, control and strength to transfer the force they produce effectively through the spinal segments and shoulders? Are there restrictions to movement that make this harder?

Movement solutions can include the use of foam rollers to increase tissue blood flow and encourage movement gains after long rows - this can be very effective when applied to the mid spine as T-type stretch. Any training that enhances movement of the spine through all planes will also be helpful and a balance of strength through all planes is vital.

As a sport we need to look at our bodies more and understand what they need to move effectively and safely to produce performance. Be kind to your ribs. ROW360

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Further References

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