ROWING STRONGER

The Research: LBP and RSI in Rowers

A research review detailing the two most common and costliest rowing injuries, and how rowing coaches, strength coaches, and athletes can work together to reduce them.

Rowing Stronger

The online home of strength training for rowing, helping you row stronger, faster, healthier, and longer since 2015.

What You're Getting Into

4,500 words, 20-25 minute read time

This is a condensed, plain English version of my final term paper from my summer Biomechanics graduate class, a research review of low back pain and rib stress injuries in rowers with an emphasis on mechanism of injury and prevention strategies. I reviewed around 35 research articles and have linked to the most relevant research throughout this article.

My goal with this resource is to provide specific education for the rowing coach, strength coach, and rower detailing the mechanism of injury, risk factors, and rowing and strength training strategies to reduce LBP and RSI in rowers.

In strength,

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Table of Contents

Limitations of Research

I want to get this out of the way first to set the expectations for the rest of the article. Research provides trends and general information based on the study methods, population of participants, and thoroughness of the researchers. Research does not provide definitive, concrete, absolute answers, nor does it deal in hyper-individualized prediction or prescription.

Coaches and practitioners then take this general information and learn to apply it to specific athletes and situations to dial it in to the individual level. A limitation of all research is that it never provides “you must do (or not do) X, Y, or Z” kind of answers. It provides general “research suggests that X, Y, and Z have an effect on…” kind of answers.

Rowing research around LBP and RSI has a few additional limitations. The biggest one is that the majority of the research is done on ergs, usually static ergs, and for now, we are left to assume that this knowledge translates to on-water rowing as well. A second limitation is that rowing encompasses a wide range of individuals from juniors to masters, rowing a range of boats from singles to eights, across a wide range of geography, all of which affect the technical and training program style, needs, and execution. Finally, researchers still do not absolutely understand the exact mechanisms of injury for either LBP or RSI. I will explain the dominant theories as to how and why these injuries occur, but they are just theories and more research is needed to understand the injuries so we can develop strong evidence-based training practices for training, recovery, and rehabilitation.

Injury Mechanism: Low Back Pain

When we talk about LBP, we're talking about non-specific LBP, which is general pain in the lumbar spine area that is NOT an injury to a disc, ligament, facet joint, or specific muscle. Those injuries have clear symptoms and causes, but non-specific LBP is the aching, chronic kind of pain that you might get some relief from after stretching or walking around, but comes back around training sessions and doesn't have one clear cause of injury. LBP affects 32-53% of rowers in 12-month studies and research indicates that this type of chronic pain is most often related to technique and training volume. Rowing is a cyclical movement pattern and the high training volume typical of endurance sports results in hundreds of repetitions of the stroke cycle during a typical training session. Rowers must accurately and consistently translate physical strength and endurance to a refined technique to produce boat motion, and technical deficiencies add up quickly in this environment to have a big effect on not only efficient boat or erg motion, but physical health as well.

Multiple studies (one, two, three) found that prolonged static erg sessions (defined as 30+ minutes continuous) resulted in technical breakdown that caused increased flexion and extension as well as side-to-side motion at the lumbar spine vertebrae. Basically, the longer you row, the more your lumbar spine begins to move past its normal range-of-motion in the rowing stroke. More flexion, or rounding, on the recovery or at the catch means more extension, or arching, on the drive and at the finish. In addition, researchers found angular displacement, or side-to-side motion, at the lumbar vertebrae as rowers rowed longer and closer to maximum output. This occurred particularly on the recovery and at higher rates, which suggests balance problems possibly the result of the athlete fatiguing. This increased lumbar spine motion occurred in novice, collegiate, and elite rowing populations, and it's bad for two major reasons.

First, to maximize transfer from training to performance, erg work should be performed as technically similarly to on-water rowing as possible. The more different erging is from on-water rowing, the less transfer of ability the athlete will get from training to performance.

Second, it results in less lower body and more upper body contribution to the stroke. Static ergs already have a higher peak force at the handle than dynamic ergs or on-water rowing, as well as greater muscle activity in the upper body. As lumbar flexion and extension increases under prolonged rowing conditions, the rate of force development decreases and the athlete reaches peak force later in the stroke cycle, further shifting the power production emphasis away from the legs and more onto the back and shoulders. The current proposed mechanism of injury is that increased ROM results in increased force, and increased force exerted on passive spinal structures that aren't prepared to handle increased force, which leads to tissue strain and chronic pain.

Injury Mechanism: Rib Stress Injury

Rib stress injury (RSI) is a catch-all term describing a spectrum of overuse injuries causing pain to the chest area. RSI affects around 10% of rowers and includes strains, stress fractures, and full fractures, which occur as a result of the bone's failure to remodel itself following microdamage from continuous mechanical loading. In simple terms, the ribs experience loading throughout each rowing stroke, and if the bone doesn't heal itself adequately following each session, an injury develops over time as more and more strokes cause more and more microdamage that the bone can't recover from. While RSIs affect fewer rowers, the time for recovery is much longer, with one study of Australian rowers recording an average of 47 lost days of training for a low grade RSI and up to 60 for a full stress fracture.

RSI are multifactorial, meaning that there isn't one single cause of injury, but a panel of significant risk factors and aggravating incidents that may lead to injury. There are a few theories of mechanism of injury, the most well-supported of which is the rib cage compression theory. The idea here is that the mid-drive phase is where the highest peak force occurs in the stroke, as does the resultant force vector of arms to oar handle and the scapular retractor muscles, which creates a compression force on the posterolateral (rear-and-outside area) rib cage. Mid-drive phase coincides with the highest reported pain in RSI rowers, and researchers have found higher co-contraction of scapular muscles in RSI rowers compared to a matched control group, suggesting that RSI rowers experience higher forces acting on the ribs during the drive phase.

The role that force plays in creating the injury is a common link between RSI and LBP mechanism of injury. The rib cage area transfers all force in the rowing stroke from the legs and torso to the shoulders, arms, and oar. So, more force in the stroke means more force on the ribs. Under prolonged and/or maximal erging, increased lumbar spine motion means increased force production from the upper body, which means increased force on the passive spinal structures and on the rib cage, which means a greater risk of injury for both LBP and RSI.

Risk Factors for Injury

Researchers noted an increase in rowing injuries, including LBP and RSI, in the early 1990s, when **hatchet blades** and static ergs became popular and commercially available. Hatchet blades have a greater surface area and catch the water faster than the Macons, or spoon-style, blades that preceded them, and researchers suggest that the increase in force production without adequate strength to support the higher output is a risk factor for LBP and RSI. Concept2 ergs became popular in rowing programs in the late 80s and early 90s and have been increasing in popularity ever since, especially with the Crossfit boom. Before this time, even programs that had ergs rarely had enough of them for all rowers to engage in high volume training programs, and those who didn't spent the off-seasons cross-training, weight-lifting, or off entirely. Commercially available ergs facilitated year-round specific rowing training in the USA, and combined with hatchet blades, greatly increased the training volume and training load of rowers at all levels. There is no doubt that the ability to increase per-stroke output and train specifically for rowing year-round also contributes heavily to the improvement in performance of the last 25 years, but researchers also note them as risk factors for LBP and RSI.

Static ergs are an excellent tool to enable rowers to train specifically for rowing year-round, in the off-season when rowable water isn't available and in-season when lineups don't work out perfectly, and a great teaching tool for focusing on specific elements of the stroke that are hard to coach on-water. However, research indicates that static machines exert a significantly higher peak force on the stroke than dynamic ergs or on-water rowing. In one study of male and female collegiate rowers, researchers found that rowers using dynamic machines decreased peak handle force by 14.8% compared to static machines. Researchers in another study found significantly greater muscle activity in the biceps, deltoids, and trapezius on static ergs compared to single sculling. More force, and more force from the upper body, means more stress on the lumbar spine and rib cage, which means more risk of LBP and RSI.

Prolonged rowing (30+ minutes continuously) on static machines is one of the most significant risk factors for both LBP and RSI. Nearly every research article examining erging and LBP (one, two, three) noted the increased ROM at the lumbar spine when rowing for 30-minute (or more) continuous pieces, increasing stretching and loading of passive spinal structures to cause tissue pain.

Static ergs are a great training tool, but like any tool, only if they are used responsibly. Static ergs already exert higher peak forces on athletes and put more stress on the upper body than dynamic ergs or on-water rowing. Under prolonged rowing conditions, this increases even further as technical breakdown occurs to put even more stress on the spine and rib cage.

Training volume is one of the other most significant risk factors. In a study of over 1600 NCAA rowers, researchers found that LBP was most likely to develop during the winter season (39%) compared to spring (33%), fall (25%), and summer (4%). Those line up almost exactly with the amount of meters and amount of time commonly spent on ergs. In a study of 76 elite rowers representing New Zealand, researchers found a high positive correlation between LBP prevalence and total training hours per month, total ergometer training hours per month, average training hours per participant per month, and average number of meters rowed per month. The authors also noted that a significant increase in new cases of LBP occurred in the month in which athletes returned to training from their off-season break and experienced a rapid increase in training load. High total training load, an accelerated path to developing high training load, and if training load is achieved with static ergometers, are significant risk factors for LBP and RSI.

In addition to training program parameters, **history of LBP and RSI** is a significant risk factor in development of future injury. The authors of the New Zealand rowing study identified history of LBP as the single most significant predictor of future incidents of LBP. 18% of the 1632 collegiate rowers in the NCAA survey began rowing before age 16, and the authors found that competitive rowing before age 16 was significantly correlated with LBP as a collegiate rower. Rowing has continued to grow since that study was conducted in 2002. As of 2016, there were approximately 40,000 US-Rowing junior members under the age of 18, 10,000 collegiate rowers, and 28,600 US-Rowing masters members over the age of 21. With a growing population of adolescent rowers, preventing the first incident of LBP and RSI is major key in reducing the injuries overall.

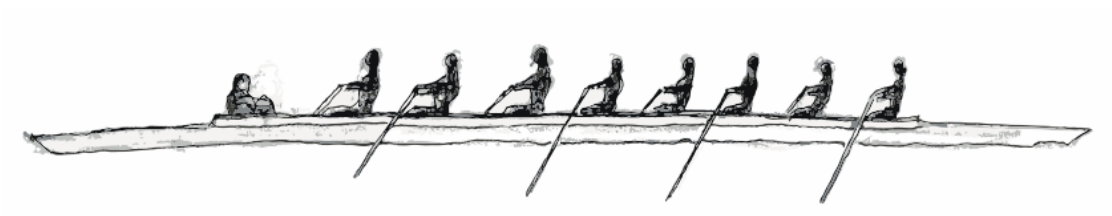
Because RSI is a bone injury, **low bone mineral density (BMD)** is also a risk factor. Researchers have found that male and female lightweight rowers are at greater risk of disordered eating, intentional weight loss, calorie restriction, and low BMD than openweight rowers, and at greater risk of RSI. In one study of 21 elite female lightweight rowers, seven participants experienced rib pain and had significantly lower lumbar spine and total body BMD than those who did not. The “female athlete triad” used to be the term for inadequate calorie intake relative to energy expenditure causing impaired menstrual function and low bone mineral density. Researchers from the International Olympic Committee redefined this in 2014 as the “Relative Energy Deficiency in Sport,” or RED-S, to reflect the fact that male athletes and female athletes alike engage in calorie restriction, are at risk for disordered eating, and that menstrual function is just one of many physiological functions impaired from inadequate calorie intake including immune system, metabolic rate, protein synthesis, psychological and cardiovascular health, and more.

Finally, **weak knee extensors (quadriceps)** are a risk factor for RSI, and **weak knee flexors (hamstrings)** are a risk factor for LBP. Researchers in one study found that RSI rowers had a lower ratio of strength between knee extensors and arm flexors, again contributing to the theory that RSI rowers row a stroke that is heavier on the upper body. Researchers in another study found that a high ratio of quadriceps-to-hamstring strength was a risk factor for LBP. The stroke does a great job of developing the quads, but a poor job of developing the hamstrings, and this imbalance may lead to LBP.

A quick recap:

- LBP is a chronic injury and occurs as a result of technical breakdown that increases ROM at the lumbar spine, stretching and loading passive spinal structures, resulting in tissue strain and pain.
- RSI is an overuse injury and occurs as a result of the bone's failure to heal itself from mechanical loading experienced during rowing training.
- Prolonged (30+ mins) static erging is the most significant risk factor. The lumbar spine increases ROM, which leads to a delayed force production profile and greater peak forces generated from the upper body, which leads to increased stretching and loading of passive spinal structures to cause tissue strain and pain.
- Most of the other significant risk factors for LBP and RSI have to do with training load and volume. High training volume, especially when that high training volume is achieved rapidly and/or with static ergs, is a significant risk factor. High load per stroke comes from hatchet blades, static ergs, low rate training, high drag erging, rowing eights by pairs or fours, and/or added resistance rowing training.
- History of LBP and RSI is another significant risk factor. Once you have one, it's more likely that you'll get a second one in the future.

Now that we've laid out the mechanisms, causes, and risk factors for these two injuries, let's get into the action plan for rowing coaches, strength coaches, and athletes, and how we can all work together to reduce risk of injury and enjoy more productive training sessions for a longer career.



Takeaways for Rowing Coaches

There are several things that rowing coaches can do to be more aware of risk factors for LBP and RSI and put strategies in place to reduce risk factors.

#1. Evaluate quantity of training load

Look at the training program and evaluate sources of high training load.

- Do we do low-rate training?
- Do we always row with hatchets?
- Do we use only static ergs, or dynamics as well, and what is the balance?
- Do we row eights by pairs and fours?
- Do we do additional load training via high-drag erging, bungee cord or other forms of resisted rowing training?

These are all forms of high-load rowing training and we should have plans in place to introduce and train these in an intentional manner that is appropriate for the competitive level, biological and training age, and physical health of the athletes we coach.

#2. Plan for gradual increases

Consider implementing a strategy to decrease, and then gradually increase, training volume and load at certain times of the training year. For example, when athletes return from summer break or other times away from structured training, consider doing a period of decreased load and/or volume training and then gradually increasing from that point, rather than throwing athletes straight back into standard rowing training, or worse, extra high load and/or volume training to "make up for lost time."

Some ways to decrease load include:

- Use spoons instead of hatchets.
- Do cross-training instead of erging.
- Use dynamic ergs instead of static ergs.
- Erg on the lowest available resistance setting.
- Avoid rowing eights by pairs or fours.
- Minimize low-rate training.

It is not the case that you need to do all of the above for *entirely* low-load training. The point of this section is to identify high-load areas in training, and have a plan to manipulate those variables appropriately for the athletes and the phase of training.

#3. Cross-train for aerobic fitness

Prolonged training on static ergs is the most significant risk factor for LBP, and a significant risk factor for RSI. The aerobic adaptations we seek with long-and-low aerobic endurance training are systemic, as functions of the total body cardiovascular pathways, and can be trained effectively in ways that do not load the spine and ribs as forcefully and repetitively as prolonged erging. Researchers recommend using dynamic ergs whenever possible, and if dynamic ergs aren't available, then using cross-training such as the stationary bike is a better option than static erging. Save your static erging for shorter distance, lower volume, higher intensity training that is more specific to rowing performance.

#4. Emphasize technique more than power output

Novice and experienced rowers alike demonstrate a drive to maintain power output, even if that means sacrificing technique. Technical degradation doesn't just negatively affect carryover to on-water performance, it's an injury risk for the two costliest rowing injuries. Consider using heart rate, rather than split, for more workouts to allow athletes to focus on maintaining technique under appropriate exertion, rather than maintaining output at any cost. Teach athletes how to achieve stroke length with lumbopelvic rotation, rather than flexion and extension of the lumbar and thoracic spine. Some spinal flexion is natural, and desirable to effectively distribute load across the vertebrae, but the majority of the power of the drive and reach on the recovery should come from pelvic rotation.

Takeaways for Strength Coaches

The #1 priority for strength coaches is to build the athlete up against injury. Performance improvement is #2.

#1. Always supervise

Strength training was noted in one study as a risk factor for LBP. However, strength training is also a research-recommended part of every rehab and prevention program. This suggests that quality supervision and instruction is the key to avoiding injuries in the weight-room as well as using strength training as part of an injury prevention protocol. Be aware of your coach-to-athlete ratio. Are we adequately staffed to supervise the load that athletes are using, their technique, and their movement quality?

#2. Educate and Communicate

One key problem with RSI is delayed diagnosis. RSI symptoms can be difficult to pin down and describe, and RSI are often misdiagnosed as a cartilage or intercostal muscle strain. This results in delayed off-loading for the athlete, and a longer recovery window. Athletes often self-treat LBP with time off or avoiding certain exercises, which might be effective in the short-term, but it fails to address the root cause of the problem in the long run. We have an ability as strength coaches to be informed on the common injuries, common symptoms, and to serve as liaison between athletes, coaches, and other staff members to oversee the recovery protocol. We are also in position to educate on reduction strategies, such as nutritional information around RED-S, supplementation information around Vitamin D for bone mineral density, and recovery protocols to improve sleep, hydration, stress management, and reduce risk of injury.

#3. Teach the movements

Strength training offers numerous opportunities to teach movements that are relevant to the rowing stroke and can reduce risk of LBP and RSI. For example, teach the hip hinge and Romanian deadlift to help athletes improve lumbopelvic coordination. This will help athletes achieve length and power in the boat through the hips, rather than through the spine. Teach scapular muscle control and how to effectively transmit force through the thoracic muscles. This will help them maintain a strong shoulder position to distribute force throughout the torso, instead of concentrating it on shoulder protraction and retraction only. Use analogies to the rowing stroke to help athletes see the carryover of strength training skills to rowing skills.

#4. Improve rowing-relevant muscle strength

Strength training for rowing plans should be specific to rowing performance, not bodybuilding, powerlifting, or programs from other sports. Include exercises to improve rowing performance, as well as exercises to target muscles that rowing fails to develop. For example, researchers in one study found that improving hamstring strength to balance quadriceps strength reduced the number of training sessions missed by LBP rowers. Although the mechanism isn't fully understood, training the serratus anterior has been shown in research to improve RSI rehabilitation protocols and I include it in my injury prevention work.

#5. NO BENCH PULLS

Bench pulls and bench presses exert high force on the rib cage and researchers suggest that they be avoided for rowers at risk of RSI. "Rowers at risk of RSI" is a pretty broad category considering the risk factors noted in the Great Britain Rowing Team RSI Guidelines. The benefit gained from these exercises is not worth the potential cost of causing or aggravating an RSI, considering how many other exercises can be used instead..

Read my full case against bench pulls here:

https://rowingstronger.com/2017/03/13/why-i-hate-the-bench-pull/

Takeaways for Rowers

There are at least 20 hours of the day when rowers are not under a rowing or strength coach's supervision. During that time, you can increase or decrease your risk of LBP and RSI. Which would you rather do?

#1. Stick to the script

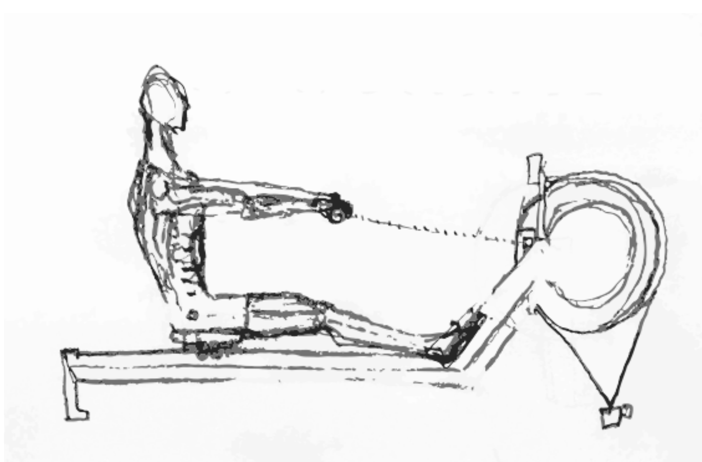
If the coach is being intentional about tracking volume, managing load, and progressing gradually, don't mess that up by adding extra sessions on your own, pulling workouts at lower splits than prescribed, or adding sets and sets of additional strength training. If you think you should be training more, ask your coach for advice.

#2. Sleep, hydrate, and eat

These are the Big 3 of recovery. Before thinking about supplements or additional training protocols, are you taking care of the basics? Athletes who sleep less than 8 hours a night have 1.7 times higher risk of injury and are nearly 3 times more likely to catch a cold. Adequate hydration, and quality as well as quantity of nutrition are critical to muscular growth, total body health, and your ability to continue improving in training. Before you add more training, add more recovery and see what happens.

#3. Dedicate to technical mastery

Rowing is a sport of power, endurance, strength, and fitness, as well as a sport of finesse to demonstrate all of those physical qualities through a highly refined technique. Remember this as you train on the water or on the erg, and seek to become a master of your craft. Just yanking on it for extra meters does little but improve aerobic fitness, and you can improve aerobic fitness on the bike even better without the risk of LBP and RSI.



Wrapping Up

LBP affects 32-53% of rowers and is the leading cause of missed training session frequency among rowing injuries. RSI affects around 10% of rowers and causes the most missed total training time, with recovery periods up to 3-8 weeks. The major proposed mechanism for LBP increased flexion, extension, and frontal plane angular displacement of the lumbar spine as a result of prolonged continuous training sessions and extreme exertion causing tissue strain and chronic pain in the lumbar area. There are three major mechanisms of injury for RSI, with the most research currently supporting the rib cage compression theory that high contraction of the serratus anterior and trapezius muscles during the mid-drive phase of the stroke exerts bending forces on the rib cage. When combined with other risk factors, this cyclical compression can cause a range of rib injuries from strain to full fracture. Both LBP and RSI are overuse injuries and share similar risk factors for injury, including training volume, rapid increases in training load or training volume, prolonged use (>30-minutes continuous) of static ergometers, and poor lumbopelvic control, coordination, and ROM.

Rowing coaches may be able to reduce risk of both LBP and RSI injury by emphasizing good technique over total power output when training on ergometers. Train the aerobic system with dynamic ergometers, or cross-training if dynamic ergometers are not available, rather than use static ergometers, to reduce lumbar tissue strain and rib cage stress. Finally, consider implementing a gradual progression of training volume and load when athletes return from the off-season or time away from regular, structured rowing training. Strength coaches should consider the hamstring-to-quadriceps strength ratio in regards to LBP and the knee-extensors-to-elbow-flexors strength ratio with regard to RSI. A strength training program that emphasizes hip ROM, lumbopelvic coordination, and strengthening of the anterior and posterior lower body as well as serratus anterior, thoracic spine, and trunk muscles may reduce risk of LBP and RSI. There is a lack of research determining evidence-based practices for rowing and strength training to reduce risk of injury, and a great practical and ethical need for more research to understand mechanism of LBP and RSI, as well as rowing and strength training practices for injury management, rehabilitation, and prevention.

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The Research on LBP and RSI in Rowers

Causes, Risk Factors, and Reduction Strategies

A research review detailing the two most common and costliest rowing injuries, and how rowing coaches, strength coaches, and athletes can reduce them.

FULL ARTICLE AVAILABLE AT ROWINGSTRONGER.COM

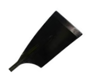
1 Mechanism of Injury

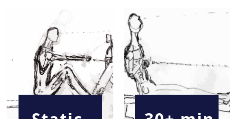
What we know about HOW the injuries occur

LBP: Chronic pain, related to technique and training volume as the spine increases ROM during the stroke, causing tissue strain and pain under increased stretching and loading.

RSI: Overuse injury, occurs as a result of the bone's failure to remodel itself following mechanical loading from the rowing stroke. High force during the drive creates rib cage compression force, produces injury over time.

RISK FACTORS





Hatchet Blades

Hatchet blades increase force output, athletes need adequate strength to handle increased output

Static Ergs

Athletes using static ergs exert higher peak force and generate more force with the upper body compared to dynamics or rowing

30+ min erging

The strongest predictor for LBP was whether or not the athlete engaged in 30+ min erging sessions on statics

High Volume

Most injuries occur during high volume periods of training: winter (39%), spring (33%), and return from breaks

Injury History

Once you get one, you are more likely to get another in the future, so preventing the FIRST incidence is key to reduction of LBP & RSI

Bone Density

RSI is a bone injury, so BMD is a main concern. Athletes eating low calorie diets are more at risk for low BMD, injury

2 Reduction for Rowing Coaches

Evaluate training load, eg. low-rate, hatchets, statics, rowing eights by pairs, added resistance rowing, etc.

Plan for gradual progression of volume and load when athletes return from breaks.

Limit prolonged erging on static machines. Use dynamics or cross-training to build aerobic base.

Technique > Split when erging. Consider using heart rate zones instead of split for training intensity.

3 Reduction for Strength Coaches

Always supervise strength training to reduce injuries in the weight-room and ensure quality of movement.

Educate & Communicate: risk factors, common injury symptoms, rehab protocols, nutrition, recovery.

Teach the movements: lumbopelvic coordination, hip ROM, scapular control, can all be taught & transferred.

Improve strength of performance muscles as well as neglected muscles for injury prevention.

NO BENCH PULLS.

4 Athletes

You have 20+ hours of un-coached time per day during which your actions can increase or decrease your risk of LBP and RSI. Which would you prefer?

No Added Training. Ask your coach if you think you should be training more than they have planned for you.

Sleep, Hydrate, Eat. Take care of the Big 3 of Recovery before you give any thought to additional training, supplements, etc.

Master Your Craft. Develop finesse of the rowing stroke, prioritize technique during training, & reap the rewards.

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