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STRENGTH TRAINING PRACTICES FOR ROWING—PART 1—REDUCING INJURIES

WILL RUTH, MA, CSCS, AND BLAKE GOURLEY, MS, FMS

Rowing is a non-contact, low-impact, competitive and recreational sport that is growing at all levels. Rowers may train and race in team boats of four or eight rowers, as well as small boats of one rower with two oars (known as the single), two rowers with one oar each (the pair), or two oars each (the double). Rowers may also compete in indoor rowing, racing on a stationary rowing ergometer (erg). The standard racing distance in indoor and on-water rowing is 2,000 m, which takes between 5.5 – 8 min to complete, depending on competitive level, age, gender, and type of boat. The rowing stroke is a cyclical movement, in which the rower places the blade in the water (or engages the chain tension on an erg), and then generates propulsive movement with the legs, back, and arms, in sequence, before removing the blade from the water and reversing movement up the sliding seat, preparing to begin another propulsive effort.

Nearly all indoor and Olympic rowing world records have occurred in the last decade, and all since 1990, thanks to increasing popularity, a greater quantity of skilled rowers, more advanced training methods, and major technological innovations. Unfortunately, injuries are more common in rowing than in other non-contact sports, and even some contact sports (22). In one prospective injury analysis of rowers, researchers found that 20 international rowers sustained 44 total injuries, for a mean injury rate of 3.67 injuries per 1,000 exposure hours (22). In another study, researchers found 72 episodes of low back pain reported by 40 international rowers, for an incidence of 1.67 low back injuries per 1,000 exposure hours (11). Injury studies indicate that 31.8 – 51% of rowers experience low back pain, and approximately nine percent experience rib stress injury (8,23). The majority of injuries in rowing are overuse injuries, resulting from a combination of poor technique, excessive load or training volume, movement limitations, muscular asymmetries, and inappropriate training practices (6,16,20,22). This article is the first in a three-part series discussing strength training practices in rowing, with the first focusing on reducing injuries in both rowing and strength training practices.

Technology may be a major reason for the increase in rowing injuries since the 1990s (18). The 1990s marked the widespread commercial availability of static stationary rowing ergometers (ergs) and hatchet blades. Before commercially available ergs, most rowers were forced to cross-train in winter months via indoor running, cycling, Nordic skiing, or make the most of sparse opportunities on early ergs. The widespread availability of static ergs made a year-round specific training approach to rowing possible, greatly increasing the total training volume (18). Static ergs also alter the technical and physiological demands of rowers, increasing load per stroke and shifting propulsive emphasis from the lower body more to the torso and upper body (23). Hatchet blades replaced the spoon-shaped Macon blades to impart more force throughout the stroke, especially earlier in the propulsive phase (8). The increased overall load from higher volume, year-round, specific rowing training, and the increased per-stroke load from static ergs and hatchet blades, increases tissue stress, and strain (6,18). This increases risk of overuse injury, particularly to the low back and ribs (6,18). Rowing coaches and strength coaches should adapt training methods for the higher load, higher volume, higher specificity landscape of 21st century rowing training.

This review will focus on two of the most common and costliest injuries in rowing: low back pain (LBP) and rib stress injuries (RSI). LBP refers to generic, non-specific, muscular pain in the sacral and lumbar spine area, not including specific injuries to discs, facet joints, ligaments, or specific muscles. LBP affects up to 53% of rowers and causes the highest frequency of missed training sessions (20,23).RSI describes a spectrum of pain in the chest wall area not caused by a muscular or cartilage injury (4). RSI affects fewer rowers, around 10%, but causes the most missed training time due to the long recovery period of a bone injury (4). Previous history of these injuries is strongly correlated with future injury, so reducing the first incidence is key to reducing overall injury rates and improving retention and performance in the sport (4,23). Strength and rowing coaches can mitigate risk factors to reduce overall injury rates with appropriate interventions for rowing technique, management of training volume and load, and muscular weaknesses.

There is a great need for evidence-based, practical resources for rowing coaches and strength coaches of rowers. We will present this information from our dual roles as strength coaches and rowing coaches, with support from relevant literature in biomechanics, physiology, and rowing-specific areas. In our experience, strength coaches and rowing coaches often have overlapping areas of responsibility. This interaction can be productive when the strength coach understands basic rowing biomechanics, and the rowing coach understands basic strength training principles. A lack of communication or basic understanding between coaches can put athlete safety at risk. Our goal is to produce a resource that can be used by strength coaches, rowing coaches, and self-coached rowers to inform training practices.

MAJOR INJURY RISK FACTORS

The first step in improving training practices and reducing injuries is identifying major risk factors that contribute to injury. RSI occur when the bone is unable to remodel itself following microdamage from continuous excessive loading (4,19). As a bone injury, low bone mineral density is a risk factor for injury (4,8). Relative Energy Deficiency in Sport (RED-S) is a term developed by the International Olympic Committee (IOC), which replaces "the female-athlete triad," that describes the physiological consequences resulting from inadequate calorie intake compared to expenditure (9). RED-S includes male athletes and impaired physiological functions beyond just menstrual function and bone health, and the consensus of the IOC is that coaches of both male and female athletes should be aware of symptoms of low energy availability and educate athletes accordingly (9). Energy deficiency is a risk in the calorie-intensive endurance training practices of rowing, especially when athletes are attempting to maintain a lower bodyweight for lightweight racing or improved short-term competitiveness (4,19).

Both LBP and RSI occur primarily due to excessive training volume and load, and technical faults in the stroke (4,20). Rowing injury researchers have made the following major findings: most LBP occurs during the winter (39%) and spring (33%) months of training, when erg training volume and intensity is highest (18); LBP prevalence is highly correlated to total training hours per month, total erg training hours per month, and average number of meters rowed per month (11); competitive rowing level is correlated to RSI incidence (8); and overall injury rates are correlated to monthly time spent on erg training, heavy strength training, and core stability training (22). These findings suggest that rowers and coaches employ excessive training volume, and achieve this training volume too rapidly, resulting in injury to the athlete. A key challenge for rowing and strength coaches is finding an athlete-appropriate training dose to elicit physiological and technical adaptation, without overtraining and increasing injury risk.

High training volume often occurs via prolonged sessions on the erg, typically defined as more than 30 min of continuous training. Remember that this type of high-load, high-volume, year-round training was not possible until the commercial availability of stationary ergs in the 1990s (18). Research on spine kinematics during prolonged erg sessions reveals a cascade of negative effects increasing stress and strain on the spine and ribcage in novice and experienced rowers alike (12,23,24). Technical proficiency at short duration or moderate intensity does not mitigate injury risk from long duration or high intensity training. Researchers have observed both novice and experienced rowers sacrificing technique under high-intensity and high-volume training conditions to maintain a given pace (23). Additionally, researchers have found increases in spinal flexion, extension, and frontal plane motion during prolonged and high-load rowing (5,12,23,24). Early drive force is also decreased, which results in a delayed point at which rowers achieve peak force, a delay in finish position, increased maximum spinal extension at the finish position, and an increase in overall magnitude of spinal flexion (5). The increased motion at the lumbar spine results in a shift of force production from the lower body to the upper body (5,12). This insidious technical deterioration increases stress and strain on the spine and rib cage, and increases risk of LBP and RSI.

Movement quality and symmetry become increasingly important as training load increases. Rowing is a cyclical motion, and rowers must manage stroke load and produce efficient movement patterns in high volumes. Athletes with good movement quality should be able to practice and compete more efficiently, given appropriate recovery time (3). Injury rates may rise if movement quality or symmetry are poor. Specifically, asymmetries at the ankles, hips, back, and thoracic spine have all been shown to contribute to back pain (2,14,15,17). Asymmetry in ankle range of motion (ROM) may cause a difference between each leg's ability to produce force. This results in a shearing force as the athlete applies pressure through the footplate, negatively affecting the rest of the kinetic chain function (2). Asymmetry in hip ROM can alter spine and pelvic mechanics. This can result in excessive spinal motion, as well as creating a shearing force at the spine (17). Asymmetry between the erector spinae muscles is the only statistically significant asymmetry found between muscle groups in rowers (15). Managing this difference may help to keep rowers healthy. A lack of rotation through the thoracic spine can contribute more stress to the lumbar spine in an already compromised position at the catch of the stroke (14). Limitations at the thoracic spine may cause excessive motion at the lumbar spine (10). These faults present challenges to spinal stability and health. Although all the asymmetries listed for back injuries can also contribute to rib injuries, the most relevant factors for rib injuries are asymmetries at the thoracic spine and the shoulders (10). A thoracic spine that lacks mobility will limit, or alter, the movement of the scapula. Altered movement at the scapula will change shoulder mechanics and potentially cause excessive stress elsewhere, such as the ribcage (10). These findings are summarized in Table 1.

TABLE 1. ASYMMETRIES OF ROWERS

ASYMMETRY	POTENTIAL INJURY	IMPLICATIONS
Hamstrings	Back	Most commonly cited cause of back pain.
Erectors	Back	The only major muscle asymmetry found in research articles. Balance out with anti-rotation work.
Ankles	Entire kinetic chain	Ankles that are uneven will create a sheering force at the hips and spine. This may also cause compensation elsewhere in the stroke.
Thoracic Spine	Back and rib cage	A lack of rotation through the thoracic spine can contribute more stress to the lumbar spine in an already compromised position at the catch.

STRATEGIES TO REDUCE ROWING INJURIES

While an informed strength training program with excellent instruction and supervision can have a positive effect on performance and resilience to injury, the strength coach cannot take sole responsibility for reducing rowing injuries. We hope that providing rowing-specific resources in this article will help strength coaches serve as a resource for rowers and rowing coaches who wish to reduce injury risk in rowing training. Remember from the earlier section on prolonged erging that the factors of technique and training load are often interrelated. We recommend that coaches consider cross-training for aerobic endurance training, including cycling, swimming, running, or other means.

Aerobic system adaptations are general and using cross-training reduces risk of injury from prolonged erging and overuse of the stroke motion muscles (8). Coaches may also consider using heart rate monitors to facilitate training at appropriate intensity, rather than erg test results. Using erg test results to calculate training zones is common practice, but we observe that it risks encouraging athletes to sacrifice technique to maintain a training pace. Heart rate or blood lactate may better reflect the exertion level of the athlete, with technique held as close to constant as possible. More injuries occur when athletes return from breaks away from regular training (11), such as following a winter holiday or summer vacation. Therefore, it is recommended to develop a plan to gradually progress training volume and load, rather than attempting to force rapid adaptation through high-volume, high-frequency training camps. Table 2 provides general strategies for evaluating and adjusting rowing training load, volume, and frequency.

There are two main purposes to strength training for rowers. First, to improve rowing performance by increasing force potential of muscles that produce stroke motion. Second, to reduce risk of injury by developing muscles and movements that rowing alone neglects. Rowers need adequate leg strength to produce force from the lower body during the propulsive phase, and upper body and torso strength to transmit and impart force from the lower body to the handle of the oar or erg. Rowers with inadequate leg strength will shift force emphasis to the torso and upper body, while rowers with inadequate upper body strength will fail to transmit force effectively from the lower body to the handle (1,18,21). Both of these faults may increase risk of injury via excess stress and strain on the spine and rib cage (12,21).

TABLE 2. VOLUME AND LOAD RISK FACTORS IN ROWING

SOURCE OF LOAD	RISK FACTOR	CONSIDERATION
Hatchet Blades	High per-stroke load, especially at the catch where blade design maximizes impulse	Use spoon-style blades when athletes return from breaks away from training, or during periods of high-volume training, to achieve aerobic and general technical adaptation with reduced load
Static Erg Training	High per-stroke load, greater upper body force contribution	Use dynamic ergs or sliders, cross-train, or adjust erg resistance to zero for aerobic endurance training
Added-Load Training (e.g., bungees, weights, rowing eights by pairs, etc.)	Higher per-stroke load is a risk factor for LBP and RSI. Athletes may alter technique to manage higher loading, resulting in more skeletal loading and technical interference	Evaluate the need for added-load training — If you choose to use added-load training, introduce it gradually, at an appropriate level for the athlete, and monitor technique carefully
Low-Rate Rowing and Erg Training	Lower boat speed increases per-stroke load	Evaluate need for low-rate training. Consider reducing load elsewhere (i.e., spoon blades, erg resistance) during phases of low-rate training
SOURCE OF VOLUME	**RISK FACTOR**	**CONSIDERATION**
Prolonged Erg Training	Technical deterioration in lumbar flexion, extension, and frontal plane motion, increases stress and strain on skeletal structures	Minimize use of prolonged erg training — Cross-train for aerobic endurance adaptations.
Year-Round Rowing Training	Overtraining and development of overuse injury	Emphasize cross-training during off-seasons.
Training Camps	High volume, high frequency, high specificity training when athletes return from time away from training risks overtraining and injury	Frequency can be high if coaches build volume and specificity gradually — Use cross-training, reduced per-stroke load training, and emphasize technical development during phases of high frequency training

Because most rowing injuries are overuse injuries, strength coaches should minimize further sources of overuse in strength training. For example, consider reducing or avoiding high repetition muscular endurance training of the legs and back when rowers are engaged in rigorous rowing training. We recommend using lower volume training for the goal of developing general strength and power. Athletes will perform sport-specific muscular endurance work in their rowing training, and strength coaches should minimize training for muscular hypertrophy or muscular endurance, to reduce further sources of volume. Coaches should use added-resistance rowing or erging very sparingly with advanced athletes only, or not at all. Added-resistance rowing methods include: towing objects behind a boat, increasing fan resistance on the erg, prolonged low-rate training, and rowing eight-oared boats by pairs. This kind of training is not an adequate substitute for strength training, and researchers indicate that the increased per-stroke load is a risk factor for LBP and RSI (4,6,13).

Strength coaches can help rowers maximize lower body contribution to the stroke by emphasizing exercises that develop the leg and (trunk) hinge muscles. Both bilateral and unilateral squat variations are beneficial for rowers, as sweep rowers (one oar per rower) may develop asymmetries in the legs and arms due to rotation in the stroke. The hip hinge develops the ability to synergistically rotate the pelvis and flex the lumbar spine. This movement is also known as lumbopelvic coordination, and it is a key feature in rowing stroke technique, effective power application, and reducing injury risk from rowing (23). Increasing spinal flexion and extension to compensate for inadequate pelvic rotation is poor technique and increases risk of LBP and RSI. Strength coaches should teach the hip hinge motor pattern to emphasize pelvic tilt with minimized spinal flexion, then train the movements and muscles using Romanian deadlifts (Figure 1), hip thrusts, kettlebell swings, and other hinge exercises. Rowers and coaches often complain of “tight hamstrings” as contributing to stroke faults, posture, and back pain, but research indicates that hamstring flexibility is not associated with low back pain in rowers (7,17). Researchers in one study of 89 competitive male and female rowers found that rowers with weak hamstrings compared to quadriceps experienced more LBP than rowers with more muscular balance, and that hamstring strengthening reduced the number of training sessions missed due to LBP (7). The researchers proposed that hamstring muscle weakness interferes with lumbopelvic coordination, increasing stress and strain on the lumbar spine (7). Strength coaches should include specific knee flexion exercises, such as leg curls, in addition to general posterior chain hip extension exercises, to strengthen the hamstrings separately from other major hip extensor muscles.

Strength coaches can help rowers improve force transfer from the lower body to the handle by strengthening the scapular muscles. The rowing stroke emphasizes development of the latissimus dorsi and upper trapezius, and, anecdotally, we observe that rowers commonly have underdeveloped shoulder external rotators, retractors, and depressors, pectorals, triceps, anterior shoulder muscles, and poor scapulohumeral rhythm. Exercises such as Y-W-T raises (Figures 2 – 4), face pulls (Figure 5), and band or cable pull-aparts (Figure 6), as well as push-ups and other horizontal and vertical pressing exercises, can strengthen these muscles, develop scapulohumeral motor coordination, and improve force transfer. Biomechanically, the goal of rowing is to improve force transfer from the footplate to the handle of the oar or erg. The entire kinetic chain must be sufficiently strong to generate and transmit this force, not just the lower body prime movers of the stroke motion (1).

We recommend unilateral exercises for the upper body as well, due to potential uneven development from stroke rotation in sweep rowers. One method for correcting asymmetries with unilateral exercise is to perform repetitions with the weaker side first, then only match those repetitions with the stronger side. This form of training can be done year-round, but, in our observation, is particularly beneficial in the off-season when intense rowing training is reduced and strength training volume can be higher. Unilateral strength training alone may not be enough to correct a major asymmetry, in which case a physical therapist should advise from a therapeutic perspective. Researchers also suggest that serratus anterior training with shoulder protraction exercises has a positive effect on RSI rehabilitation and reduction (8). Although these upper body muscles are not all rowing stroke prime movers, their development is important to reducing injury risk and improving rowing performance by distributing stroke force across muscles, rather than skeletal structures, and mitigating imbalances that may lead to injury.

Strength coaches can play a critical role in improving movement quality during land and water rowing training. In our experience, rowing coaches often attempt to address technical faults with drills and explicit instruction, when an evaluation of the athlete’s movement reveals an imbalance or structural problem restricting their ability to achieve the desired position. Table 3 provides some examples of rowing errors and their connection to movement dysfunction based on our practical experience, with pictures to illustrate common technical errors and movement dysfunctions. Four critical areas of evaluation in rowers are recommended: ankle, hip, trunk, and rotation. Researchers suggest that these asymmetries are linked to injury risk, including LBP and RSI (2,14,15,17). Strength coaches may identify limitations, then address them with appropriate interventions for soft tissue work, stretching, corrective exercise, core training, and specific strength training. Include targeted exercises at the beginning of each session, presented in a non-fatiguing context with the goal of enhancing neural activity and improved musculature control, to help athletes improve movement in subsequent exercises, improving training efficacy and reducing risk of injury.

TABLE 3. COMMON TECHNICAL ERRORS

MOVEMENT	TECHNICAL ERROR	COMMON PAIN SEEN
Ankle Mobility (Figures 7 and 8)	Lack of compression, bad body position at the catch, collapse into the catch.	Back and knee pain
Hip Mobility (Figures 9 and 10)	Lack of forward body angle, butt tucks underneath them as they approach the catch.	Back pain
Shoulder Mobility (Figures 11 and 12)	Shoulders round forward at the catch and finish, excessive reach at the catch, difficulty with rotating into the catch, and controlling the body into the catch. Upper back posture is excessively rounded.	Shoulder, back, and rib pain
Thoracic Mobility (Figures 13 and 14)	Trouble finding connection (shoot butt, swing early, or shrug). Rounding of the back as they pick up (a visible change in spine position).	Back and shoulder pain
Overhead Squat	Collapse into the catch, pick-up with the back too early. Bad body position into the catch.	Back and knee pain

CONCLUSION

Rowing is a non-contact sport, and coaches have influence over the majority of the injury mechanisms. We can reduce injuries and improve performance by increasing understanding of common risk factors and developing specific interventions with rowers and rowing coaches for training load, movement limitations, muscular imbalances, and systemic recovery. By reducing risk factors, we can reduce the first occurrence of injury and overall incidence. Reducing injury rates increases practice opportunities per athlete, number of athletes available to practice, and numerous other advantages for sport performance, long-term development, and quality of life. We will discuss strength and conditioning training to directly improve rowing performance in parts two and three of this series.

REFERENCES

1. Baudouin, A, and Hawkins, D. A biomechanical review of factors affecting rowing performance. *British Journal of Sports Medicine* 36: 396-402, 2002.

2. Buckeridge, E, Bull, A, and McGregor, A. Biomechanical determinants of elite rowing technique and performance. *Scandinavian Journal of Medicine and Science in Sports* 25(2): e176-e183, 2015.

3. Cook, G. *Athletic Body in Balance: Optimal Movement Skills and Conditioning for Performance*. Champaign, IL: Human Kinetics; 2003.

4. Evans, G, and Redgrave, A. Great Britain rowing team guideline for diagnosis and management of rib stress injury: Part 1. *British Journal of Sports Medicine* 50: 266-269, 2016.

5. Holt, P, Bull, A, Cashman, P, and McGregor, A. Kinematics of spinal motion during prolonged rowing. *International Journal of Sports Medicine* 24(8): 597-602, 2003.

6. Hosea, T, and Hannafin, J. Rowing injuries. *Sports Health: A Multidisciplinary Approach* 4(3): 236-245, 2012.

7. Koutedakis, Y, Frischknecht, R, and Murthy, M. Knee flexion to extension peak torque ratios and low-back injuries in highly active individuals. *The International Journal of Sports Medicine* 18(4): 290-295, 1997.

8. McDonnell, L, Hume, P, and Nolte, V. Rib stress fractures among rowers: Definition, epidemiology, mechanisms, risk factors and effectiveness of injury prevention strategies. *Sports Medicine* 41(11): 883-901, 2011.

9. Mountjoy, M, Sundgot-Borgen, J, Burke, L, Carter, S, Constantini, N, Lebrun, C, et al. The IOC consensus statement: beyond the female athlete triad—relative energy deficiency in sport (RED-S). Accessed July 31, 2019 from https://bjsm.bmj.com/content/48/7/491.

10. Muscolino, J. The thoracic spine: The silent saboteur. *Journal of the Australian Traditional-Medicine Society* 23(4): 192-198, 2017.

11. Newlands, C, Reid, D, and Parmar, P. The prevalence, incidence and severity of low back pain among international-level rowers. *British Journal of Sports Medicine* 49: 951-956, 2015.

12. Ng, L, Campbell, A, Burnett, A, Smith, A, and O'Sullivan, P. Spinal kinematics of adolescent male rowers with back pain in comparison with matched controls during ergometer rowing. *Journal of Applied Biomechanics* 31(6): 459-468, 2015.

13. Ogurkowska, M, Kawałek, K, and Zygmańska, M. Biomechanical characteristics of rowing. *Trends in Sport Sciences* 22(2): 61-69, 2015.

14. Ogurkowska, M. Analysis of radiological characteristics distribution in the vertebral bodies of the lumbosacral spine of competitive rowers. *Biology of Sport* 27(3): 213-219, 2010.

15. Parkin, S, Nowicky, A, Rutherford, O, and McGregor, A. Do oarsmen have asymmetries in the strength of their back and leg muscles? *Journal of Sports Sciences* 19(7): 521-526, 2011.

16. Smoljanovic, T, Bojanic, I, Hannafin J, Hren, D, Delimar, D, and Pecina, M. Traumatic and overuse injuries among international elite junior rowers. *American Journal of Sports Medicine* 37: 1193-1199, 2009.

17. Stutchfield, B, and Coleman, S. The relationships between hamstring flexibility, lumbar flexion, and low back pain in rowers. *European Journal of Sport Science* 6(4): 255-260, 2006.

18. Teitz, C, O'Kane, J, Lind, B, and Hannafin, J. Back pain in intercollegiate rowers. *The American Journal of Sports Medicine* 30(5): 674-679, 2002.

19. Thornton, J, and Vinther, A. Prevention of rib stress injury in rowers. What do we know and where do we need to go? *Sports Orthopaedics and Traumatology* 34(3): 278-286, 2018.

20. Thornton, J, Vinther, A, Wilson, F, Lebrun, C, Wilkinson, M, Di Ciacca, S, et al. Rowing injuries: An updated review. *Sports Medicine* 47(4): 641-661, 2017.

21. Vinther, A, Kanstrup, I, Christiansen, E, Alkjaer, T, Larsson, B, Magnusson, S, et al. Exercise-induced rib stress fractures: Potential risk factors related to thoracic muscle co-contraction and movement pattern. *Scandinavian Journal of Medicine and Science in Sports* 16(3): 188-196, 2006.

22. Wilson, F, Gissane, C, Gormley, J, and Simms, C. A 12-month prospective cohort study of injury in international rowers. *British Journal of Sports Medicine* 44: 207-214, 2010.

23. Wilson, F, Gissane, C, and McGregor, A. Ergometer training volume and previous injury predict back pain in rowing; Strategies for injury prevention and rehabilitation. *British Journal of Sports Medicine* 48(21): 1534-1538, 2014.

24. Wilson, F, Gormley, J, Gissane, C, and Simms, C. The effect of rowing to exhaustion on frontal plane angular changes in the lumbar spine of elite rowers. *Journal of Sports Sciences* 30(14): 1481-1489, 2012.

ABOUT THE AUTHORS

Will Ruth is a former high school rower who returned to the sport with the Western Washington University men's rowing team, coaching there for several years as the Strength Coach and On-Water Assistant Coach. Ruth moved to Vermont in 2019, and is now a guest coach at the Craftsbury Sculling Center. He is the author of the website RowingStronger.com and the book "Rowing Stronger: Strength Training to Maximize Rowing Performance," a strength training resource for rowers and rowing coaches of all levels.

Blake Gourley is a former collegiate rower who experienced a back injury that ended his rowing career and began his coaching career. He has spent over a decade coaching rowing and strength training for rowers at numerous levels, drawing on his personal experience, education, and internships to help rowers improve performance and reduce risk of injury. Gourley is currently the owner of Movement Evolution Performance Training and RowingStrength.com. He is also the Injury and Performance Management Consultant for the Los Gatos Rowing Club and a board member for the Sports Medicine Certificate at West Valley College.

FIGURE DESCRIPTIONS

Figure 1. The Romanian deadlift is an exercise for the posterior chain muscles. The lifter stands upright with a barbell or dumbbell, feet approximately shoulder-width apart, then creates the hip hinge motion of bending slightly at the knees and inclining the torso while pushing the hips back. At terminal flexibility, the lifter contracts the posterior chains muscles to return to the upright position.

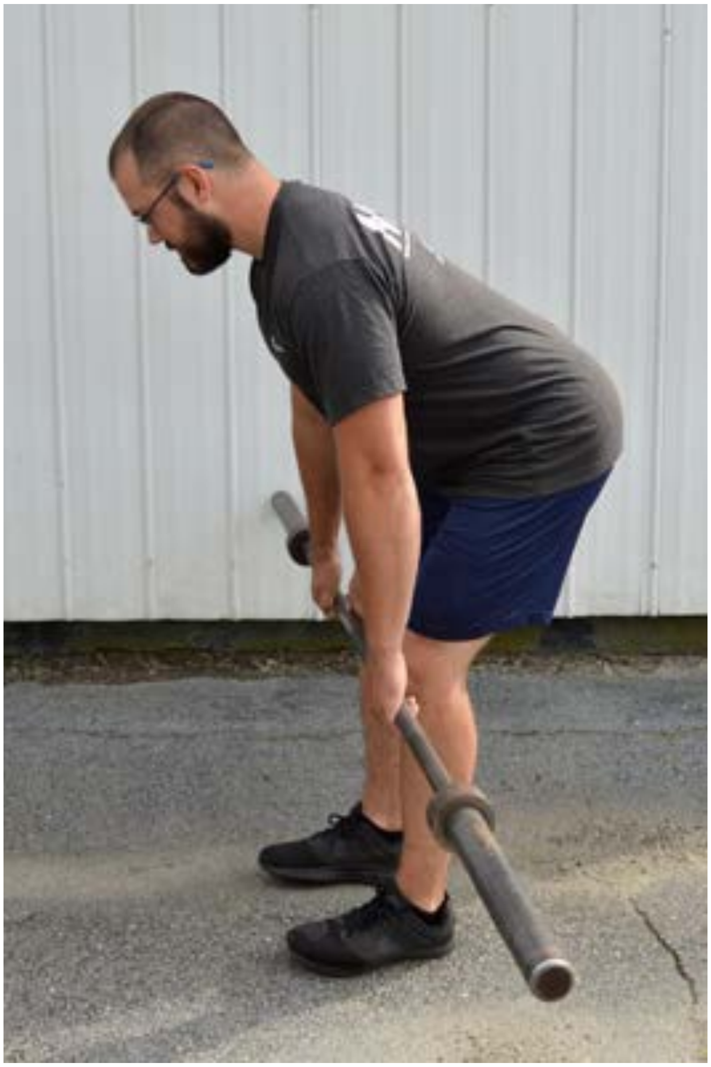

FIGURE 1. ROMANIAN DEADLIFTS

Figures 2 – 4. The Y-W-T raise is an exercise for the scapular muscles. The lifter assumes the hip hinge position, bending at the knees and inclining the torso, then raises the arms to form the letters "Y," "W," and "T," with an emphasis on scapular depression and retraction.

Figure 5. The face pull is an exercise for the scapular muscles. Using a band or cable machine with a rope handle, the lifter stands upright, sets the line of pull at face-height, bends the elbows, and draws the handle toward the face, with an emphasis on scapular depression and retraction.

FIGURE 2. Y RAISES

FIGURE 3. W RAISES

FIGURE 4. T RAISES

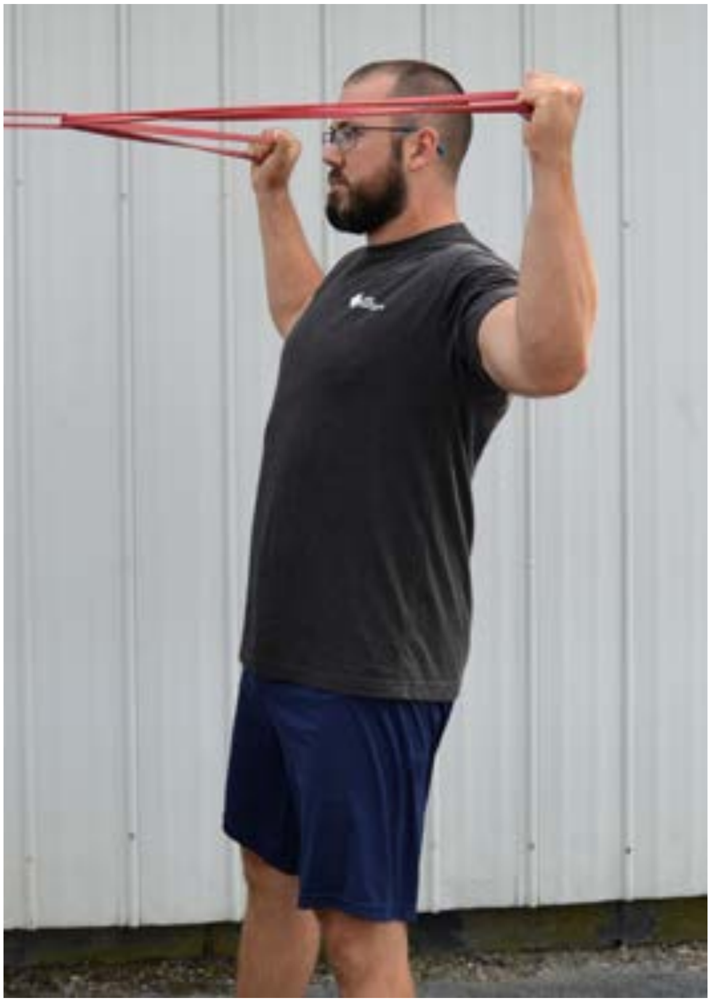

FIGURE 5. FACE PULLS

Figure 6. The pull-apart is an exercise for the scapular muscles. The lifter stands upright with arms outstretched ahead and parallel to the floor, grasps a single band with both hands, and pulls the band apart until the band contacts the torso, with an emphasis on scapular depression and retraction.

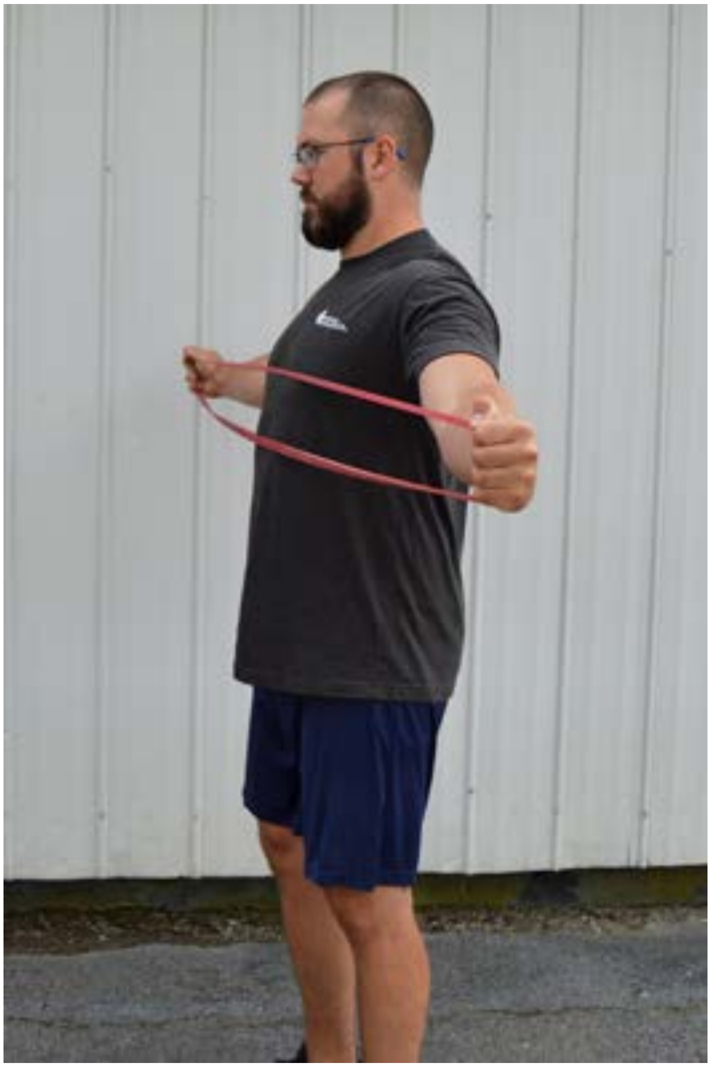

FIGURE 6. PULL-APARTS

Figure 7. In "ankle mobility—correct," the rower demonstrates proper ankle positioning at the beginning of the propulsive phase of the stroke. Heels are slightly elevated and shins are perpendicular to the floor.

FIGURE 7. ANKLE MOBILITY—CORRECT

Figure 8. In "ankle mobility—incorrect," the rower demonstrates faulty ankle positioning at the beginning of the propulsive phase of the stroke. Heels are excessively raised and shins are not perpendicular to the floor.

FIGURE 8. ANKLE MOBILITY—INCORRECT—EXCESSIVLEY RAISED HEELS

Figure 9. In "hip mobility—correct," the rower demonstrates proper hip positioning at the beginning of the recovery phase of the stroke. The rower is in a seated hip hinge position.

FIGURE 9. HIP MOBILITY—CORRECT

Figure 10. In "hip mobility—incorrect," the rower demonstrates faulty hip positioning at the beginning of the recovery phase of the stroke. The rower is in a position of excessive lumbar rounding, with minimal pelvic tilt.

FIGURE 10. HIP MOBILITY—INCORRECT—EXCESSIVE LUMBAR ROUNDING

Figure 11. In "shoulder mobility—correct," the rower demonstrates proper shoulder positioning at the completion of the propulsive phase of the stroke. Scapulae are retracted and depressed.

FIGURE 11. SHOULDER MOBILITY—CORRECT

Figure 12. In "shoulder mobility—incorrect," the rower demonstrates faulty shoulder positioning at the completion of the propulsive phase of the stroke. Scapulae are elevated and upwardly tilted.

FIGURE 12. SHOULDER MOBILITY—INCORRECT—ELEVATED SCAPULAE WITH UPWARD TILT

Figure 13. In "thoracic mobility—correct," the rower demonstrates proper thoracic positioning at the beginning of the propulsive phase of the stroke. Scapulae are depressed and slightly protracted, with cervical spine neutral.

Figure 14. In "thoracic mobility—incorrect," the rower demonstrates faulty thoracic positioning at the beginning of the propulsive phase of the stroke. Scapulae are excessively protracted and upwardly elevated, with cervical spine in protraction.

FIGURE 13. THORACIC MOBILITY—CORRECT

FIGURE 14. THORACIC MOBILITY—INCORRECT—EXCESSIVE SCAPULAE PROTRACTION

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STRENGTH TRAINING PRACTICES FOR ROWING—PART 2—STRENGTH TRAINING FOR PERFORMANCE

WILL RUTH, MA, CSCS, AND BLAKE GOURLEY, MS, FMS

INTRODUCTION

This article is the second of a series of articles on strength training practices for rowing. Part one presented risk factors for low back pain and rib stress injuries in rowers, and recommended strength training methods to reduce the risk of injury. Low back pain is the most common rowing injury, affecting up to 53% of rowers and causes the greatest frequency of missed training sessions (34,35). Rib stress injury affects fewer rowers, approximately 10%, but causes up to 60 days of missed training due to the long recovery of a bone injury (13). Rowers can reduce risk of injury by developing the muscular system to transmit force from biomechanically sound positions in the rowing stroke. This helps to distribute stroke force across muscles, rather than skeletal structures. It is recommended to use a variety of exercises for the lower and upper body that focus on the hip hinge and scapular retraction movement patterns, which are of chief importance in the rowing stroke. It is also important to develop the muscles neglected by the rowing stroke. For example, although the pectoral and triceps muscles contribute minimally to rowing stroke performance, upper body pressing exercises, such as push-up variations, are recommended to improve shoulder girdle stability and muscular balance. This may help avoid potential muscular imbalances, postural problems, and risk of injury.

Reducing injuries also has a performance-enhancing effect, as it can maximize athlete availability to practice and race. This offers more opportunities for athletes to improve aerobic fitness, technique, strength, and other important qualities of rowing performance. This second article of the series focuses on strength training for rowing performance. Increasing general force potential can improve peak stroke power, endurance at submaximal intensities, and the ability to achieve technical positions required in rowing. This article will also provide information on periodization strategies for rowers of different competitive levels and schedules, as well as include sample periodization plans and sample programs to demonstrate key programming strategies.

WHY ROWERS NEED STRENGTH TRAINING

Researchers investigating factors influencing rowing performance have found that height, limb length, body weight, body fat percentage, lean mass percentage, leg strength, grip strength, and the ability to produce large amounts of lower-body and rowing-specific power are significantly correlated with success in rowing (4,5,8,11,16,20,25,27,31). With the exception of height and limb length, strength and conditioning coaches and rowers can work to develop all of these qualities, alongside other important variables like aerobic fitness and rowing technique. Although some strength and conditioning coaches and rowers debate that rowing alone is enough to develop sufficient strength for rowing, researchers have found that combining strength training with rowing training is more effective for performance than rowing training alone (1,14,21,36).

The speed and weight of the rowing stroke are two important factors for strength training for rowers. Drive speed is critical for rowing performance and may be even more important to rowing performance after substantial strength has been established (11,23). Rowers must contend with the external resistance of water and the combined weight of teammates and equipment in the boat. This weight is highest at the beginning of the race, when the boat is at rest in the water. The load decreases after the first several strokes, but varies throughout the stroke itself, and phase of the race. Researchers indicate that the average weight of the stroke over a 2,000-m race is between 56 – 166 lb, dependent on numerous external factors, such as the size and set-up of the boat, weight of teammates, weather factors, and phase of the race (22). The maximum weight of the stroke is 118 lb for female rowers and 165 lb for male rowers (22). Athletes who can proficiently develop this force in a stable environment, via lifts such as the squat and deadlift, should be able to safely engage in training for the unstable and high-fatigue environment of rowing. Increasing strength beyond prerequisite levels should improve rowing performance, as a stronger rower will be able to deliver more propulsive force per stroke and maintain submaximal stroke force for longer durations.

Some rowers hold the common fear among endurance athletes that gains in strength and muscle mass interfere with sport performance (12). This fear is largely unfounded as long as body fat accumulation is minimized, and range of motion (ROM) and aerobic fitness are maintained. In a study of male and female collegiate heavyweight rowers performing concurrent strength training and rowing training, researchers found that improvements in muscular strength and lean body mass were positively correlated with improved 2,000-m performance (36). Subjects performed strength training one or two days per week alongside five weekly rowing training sessions. Strength training sessions consisted of full-body, free-weight compound exercises performed for 3 – 5 sets of 2 – 20 repetitions, depending on the phase of training. Over the nine-month study period, rowers improved 2000-m rowing performance, increased lean body mass, and decreased body fat percentage. This finding is significant, and supports the use of year-round, concurrent strength training with rowing training to improve performance and body composition.

EXERCISE SELECTION FOR ROWERS

Due to the load and speed of the rowing stroke, there is a connection between muscular strength and rowing technique. For example, rowers with weak knee extensors may compensate by shifting force generation to stronger areas of the body, commonly the spinal extensors. There are two common errors when this occurs. Firstly, the rower may "shoot the slide," in which the knees extend weakly without maintaining torso position, causing the athlete to miss early drive propulsive force. Secondly, the rower may compensate for weak knee extension by summoning forces from the torso and upper body muscles, often referred to in rowing as "opening early," which results in a loss of late drive propulsive force. These may appear as technical errors when strength deficiency is the greater problem. Improving knee extension strength may improve the athlete's early drive force and seat-to-handle technical connection, improving rowing technique and performance. Exercise selection is important to increase general muscular force potential with the goal of improving rowing performance. The following recommendations are intended for the competitive female or male rower with strength training experience. The female and male competitive parameters are the same in rowing. Both men and women race the same distances, under the same rules and conditions, and generally use the same equipment. Strength and conditioning coaches should consider the training experience of the rower in determining the best exercises and programming strategies.

LOWER BODY EXERCISE SELECTION

The major lower body muscles producing rowing stroke motion are the leg and hip extensors, including the quadriceps, gluteus maximus, hamstrings, and spinal erectors (19). Bilateral power is sport-specific to rowing, and rowers should use bilateral squat and deadlift exercises to develop bilateral lower body power (2,8,29). The front squat and hex bar deadlift may be superior squat and deadlift variations for rowers. Both front squats and hex bar deadlifts offer effective means of developing lower body strength and power (6,17,33). The front squat and hex bar deadlift are performed with an upright torso and hip-width stance, which makes them more similar to the biomechanical position of the rowing stroke. Researchers have also found that the hex bar deadlift reduces spinal shear stress compared to the barbell deadlift (33). This may reduce stress and strain to the lumbar spine, a vulnerable area for rowers. From personal experience, we will typically perform these exercises as "main work" for multiple sets of low reps, one or two times per week, with the goal of developing strength and power to increase general force potential for rowing. For example, 3 – 5 sets of 3 – 8 repetitions, in the 70 – 85% one repetition maximum (1RM) range, with 2 – 4 min of rest.

In our coaching practice, we follow these exercises in a training session with assistance work intended to further build lower body strength and muscle mass. These lifts are often categorized as squat and hinge movements, and include both bilateral and unilateral exercises. For example, the unilateral squat exercises of the rear-foot-elevated split-squat and the single-leg squat, and the hinge exercises of the kettlebell swing, glute-hamstring raise, and the single-leg, straight-leg deadlift. We will typically perform one or two of these exercises per session, after the main work, for multiple sets of higher repetitions, with the goal of developing general muscular strength and hypertrophy. For example, we will perform 3 – 5 sets of 6 – 12 repetitions, in the 65 – 80% 1RM range, with 1 – 3 min of rest.

UPPER BODY EXERCISE SELECTION

The major upper-body muscles producing stroke motion are the shoulder extensors, shoulder retractors, and elbow and forearm flexors. While the upper-body muscles play less of a role in propulsive stroke motion than the lower-body muscles, they are still important to rowing performance for force generation and transmission. Grip strength is important for rowing performance (30). Forces generated from the lower body and torso muscles must be transferred through the hands to impart force in the stroke (3). Rowing training itself is a grip-intensive activity, and we recommend that strength and conditioning coaches only use specific grip exercises with rowers during off-season periods of non-rigorous rowing training. We have observed that general free-weight strength training consisting of barbell, dumbbell, and kettlebell exercises, performed mostly without the aid of grip straps, is sufficient stimulus for most rowers, without overtaxing the forearm flexors when combined with rowing training.

We recommend a combination of compound exercises and more focused minor exercises for these upper body muscle groups. For example, the overhead push press and standing barbell row are two compound exercises that train the major upper body muscle groups, and also train athletes to transfer force from the floor through a stable torso to an implement held in the hands. This is similar to the general motor coordination of the rowing stroke. We will also use exercises focused on specific muscular development. For example, the unilateral dumbbell row, batwing row (Figures 1 and 2), x-band row (Figures 3 and 4), and chin-up or pull-down variations. We will typically perform one compound upper-body exercise for moderate sets and repetitions to develop strength and power. Additionally, we will perform 1 – 3 exercises focused on muscular development for multiple sets of higher repetitions to develop general muscular strength and hypertrophy. Upper body training within a session may include 3 – 5 sets of 5 – 10 repetitions on a compound exercise, with 2 – 4 min of rest, followed by 2 – 4 sets of 6 – 12 repetitions on more specific muscular exercises, with 1 – 3 min of rest.

CORE TRAINING EXERCISES

The trunk extensor and flexor muscles are important for trunk stabilization and stroke force transmission. Researchers studying muscle activity in the rowing stroke suggest that the primary torso stabilizers in the early drive phase are the trunk and hip extensors (28). The trunk flexors activate most strongly in the late drive phase, supplying a braking force against the trunk extension in the middle drive phase (28). This suggests that rowers should train the trunk extensor muscles, such as the spinal erector muscle group and the hip extensors of the gluteus and hamstring muscles. We recommend exercises such as the Romanian deadlift, kettlebell swing, and band or cable pull-through to build strength, power, and endurance in these areas.

While isometric exercises, like the plank hold, are useful at a beginner level, we recommend that rowers train the trunk flexors in a stroke-specific manner, including movement at the hips. For example, in the "erg plank" exercise (Figures 5 – 7) and the ab wheel (Figures 8 and 9), the athlete must maintain a stable torso while moving through hip flexion and extension. Full-body, compound exercises, such as squat, deadlift, overhead press, and row exercises, also train trunk stability with movement at the hips, and are important components of overall trunk strengthening (18).

PLYOMETRICS AND WEIGHTLIFTING VARIATIONS

Multiple researchers have identified peak rowing power as the most significant factor for 2,000-m rowing performance (5,8,10,11,20). Strength and conditioning coaches and rowers should emphasize power development in their training program after developing sufficient strength. There are many ways to introduce and develop the ability to produce power. Rowers may perform standard free-weight lifts with an emphasis on concentric acceleration; incorporate plyometrics, such as box jumps and medicine ball throws, and use specific methods like the kettlebell swing or strength and power contrast training to improve power production. Plyometrics may increase drive speed and help rowers impart greater peak force when rowing (11). Weightlifting exercises, such as the clean, snatch, and their variations, are commonly included in rowing programs (15). If athletes are sufficiently experienced and develop proficient technique, clean and snatch variations may be worth including in a training program, especially during a power development training phase. These lifts should not be used for high-repetition, muscular endurance training due to increased risk of injury from technique degradation under fatigue.

EXERCISE MODIFICATIONS FOR ROWERS

Rowers vary greatly in height and physical proportions, depending on age and competitive level. The most competitive rowers tend to be tall, with long limbs, which maximizes leverage on the oar and the amount of propulsive phase time during which the rower can impart force on the oar. The ideal physical build for rowing is not the ideal physical build for lifting maximal weights. Ability-based exercise modifications may be necessary to allow athletes of different proportions to perform lifts safely and effectively, while building general muscular strength (9,26). Common modifications to the above major exercises include: elevated push-up (Figures 10 and 11), reduced-ROM squat (Figures 12 and 13), elevated deadlift (Figures 14 and 15), band-assisted chin-up (Figures 15 and 16), and hex bar deadlift (Figures 18 and 19). We may address the restriction limiting the athlete from achieving the full-ROM variation of the lift, such as hip mobility to achieve greater squat depth. However, we often find that performing the modifications is self-correcting; for example, performing the hands-elevated push-up develops the requisite strength in the chest, shoulders, and triceps to progress to the full-ROM push-up. In other cases, the athlete may never need to perform the full-ROM exercise, such as the barbell conventional deadlift from the floor, due to individual biomechanics and a lack of need to comply to arbitrary ROM standards.

PERIODIZATION OF STRENGTH TRAINING FOR ROWING

Periodization is a system of organized training, which takes into account the specific demands of rowing training over the course of a year. In the first article of this series, we recommended minimizing hypertrophy and muscular endurance strength training when rowers are engaged in rigorous rowing training. The majority of rowing injuries are overuse injuries due to high load and/or the volume of training (19). Strength training load and volume is part of the overall training load. It is important that rowers have an off-season time away from rigorous rowing training. This time can be used for higher volumes and varieties of strength training to improve base strength, muscle mass, and body composition. As rowers approach more rigorous in-season rowing training, strength training becomes more focused on specific exercises and methods of training to improve rowing performance.

Many different periodization models exist, and it is outside the scope of this article to present an exhaustive review of each. In the block periodization strength training paradigm, athletes will progress from hypertrophy development in the general preparation block, to strength development in the specific preparation block, then power development in the pre-competitive block, and then maintain all qualities to achieve peak performance in the competitive block (24). The block periodization system fits well to a typical rowing schedule of junior and collegiate rowers. Junior and collegiate rowers tend to have a summer off-season; a fall on-water season consisting of longer-distance rowing and racing; a winter pre-season consisting of indoor work on stationary rowing machines and a greater focus on anaerobic training; and a spring on-water season racing sprint races, as the main competitive focus of the year. Table 1 demonstrates the alignment of rowing and strength training goals from this periodization framework, as an example annual plan for a northern hemisphere, spring season, 2,000-m rower. This schedule can be adjusted for a rower who specializes in the fall season, longer-distance races, or for the post-collegiate (masters) rower who may use a different competitive schedule.

Rowers may race at ten or more events in a given training year; tapering and peaking for each race would be take away from training time. Strength and conditioning coaches and rowing coaches should communicate to determine priority races, weeks of more intensive training, and important erg tests or seat-selection intrasquad racing. Strength and conditioning coaches may consider adjusting the strength training session immediately before non-priority races or other important events, without performing an entire taper. For example, a strength and conditioning coache could consider reducing volume, intensity, or avoiding eccentric exercises, which could decrease muscular soreness and fatigue for racing (7,14). Additionally, rowing often involves up to an entire day of travel to and from a race event. This time is spent removing the rigging equipment from the boats, loading the boats and equipment onto a trailer, traveling to the race location, unloading the trailer, and re-rigging the boats for rowing, before doing it all again after racing is concluded. While this is not physically strenuous, it is time-intensive and laborious, and should be accounted for in the overall training program with adequate recovery time around competitive events.

SAMPLE PROGRAM WEEKS

Tables 2 – 5 outline example weeks of training based on the information above. The intent is to demonstrate the concepts of exercise selection, periodization, and programming in the different phases of training. Exercise selection is presented in the form of categories to encourage strength and conditioning coaches to consider their own individual coaching context. For example, the age and stage of the athletes; potential exercise modifications; available equipment, space, and time for strength training; and the goals of the athletes and current phase of training.

CONCLUSION

Strength training for rowing performance involves improving general force production in the rowing stroke muscles of the leg, pelvic, trunk, and shoulder extensors, and the elbow and forearm flexors. Strength and conditioning coaches should use a combination of higher-load, lower-repetition exercises to improve maximal strength and power, and lower load, higher repetition exercises for muscular development. A periodized strength training plan for rowing should take into account the off-season phase of reduced rowing training, the distance racing season, the sprint racing season, and any training schedule variations within the rowing programs, and between groups of rowers. A periodized approach is particularly important for rowers due to the high energy demands of rowing training, creating a need to make use of reduced rowing training in the off-seasons to pursue strength and muscular development. The next article in this series will address conditioning practices to improve rowing performance.

REFERENCES

1. Abdelsalam, H, Ellouzy, M, and Gaber, M. Effect of concurrent training on cd34+/cd45 stem cells, vo2max, certain physical variables and record level of 2000m rowing. *Ovidius University Annals, Series Physical Education and Sport/Science, Movement and Health* 14(1): 78-84, 2014.

2. Akca, F. Prediction of rowing ergometer performance from functional anaerobic power, strength and anthropometric components. *Journal of Human Kinetics* 41: 133-142, 2014.

3. Baudouin, A, and Hawkins, D. A biomechanical review of factors affecting rowing performance. *British Journal of Sports Medicine* 36: 396-402, 2002.

4. Bootes, M. The relationship between rowing ergometer power and jumping characteristics. *Journal of Australian Strength and Conditioning* 25(6): 50, 2017.

5. Bourdin, M, Messonnier, L, Hager, J, and Lacour, J. Peak power output predicts rowing ergometer performance in elite male rowers. *International Journal of Sports Medicine* 25(5): 368-373, 2004.

6. Camara, K, Coburn, J, Dunnick, D, Brown, L, Galpin, A, and Costa, P. An examination of muscle activation and power characteristics while performing the deadlift exercise with straight and hexagonal barbells. *Journal of Strength and Conditioning Research* 30(5): 1183-1188, 2016.

7. Cheung, K, and Hume, P. Delayed onset muscle soreness. *Sports Medicine* 33(2): 145-164, 2003.

8. Chun-Jung, H, Nesser, T, and Edwards, J. Strength and power determinants of rowing performance. *Journal of Exercise Physiology Online* 10(4): 43-50, 2007.

9. Clayton, N, Drake, J, Larkin, S, Linkul, R, Martino, M, Nutting, M, and Tumminello, N. Foundations of fitness training. *National Strength and Conditioning Association*: 2015.

10. Dong-Rour, L, and Laurentius, J. Effects of hand grip exercise on shoulder joint internal rotation and external rotation peak torque. *Journal of Back and Musculoskeletal Rehabilitation* 29(3): 521-525, 2016.

11. Egan-Shuttler, J, Edmonds, R, Eddy, C, O'neil, V, and Ives, S. Beyond peak, a simple approach to assess rowing power and the impact of training: A technical report. *International Journal of Exercise Science* 12(6): 233-244, 2019.

12. Erickson, T. The benefits of strength training for endurance athletes. *NSCA's Performance Training Journal* 4(2): 13-17, 2005.

13. Evans, G, and Redgrave, A. Great Britain rowing team guideline for diagnosis and management of rib stress injury: Part 1. *British Journal of Sports Medicine* 50: 266-269, 2016.

14. Gee, T, Caplan, N, Gibbon, K, Howatson, G, and Thompson, K. Investigating the effects of typical rowing strength training practices on strength and power development and 2,000 m rowing performance. *Journal of Human Kinetics* 50(1): 167-177, 2016

15. Gee, T, Olsen, P, Berger, N, Golby, J, and Thompson, K. Strength and conditioning practices in rowing. *Journal of Strength and Conditioning Research* 25(3): 668-682, 2011.

16. Gee, T, Olsen, P, Fritzdorf, S, White, Golby, J, and Thompson, K. Recovery of rowing sprint performance after high intensity strength training. *International Journal of Sports Science and Coaching* 7(1): 109-120, 2012.

17. Gullet, J, Tillman, M, Gutierrez, G, and Chow, J. A biomechanical comparison of back and front squats in healthy trained individuals. *Journal of Strength and Conditioning Research* 23(1): 284-292, 2009.

18. Hamilyn, N, Behm, D, and Young, W. Trunk muscle activation during dynamic weight-training exercises and isometric instability activities. *Journal of Strength and Conditioning Research* 21(4): 1108-1112, 2007.

19. Hosea, T, and Hannafin, J. Rowing injuries. *Sports Health: A Multidisciplinary Approach* 4(3): 236-245, 2012.

20. Ingham, S, Whyte, G, Jones, K, and Nevill, A. Determinants of 2,000 m rowing ergometer performance in elite rowers. *European Journal of Applied Physiology* 88(3): 243-246, 2002.

21. Jaakson, E, and Maestu, J. The impact of low intensity specific and nonspecific strength-endurance training on submaximal work capacity in trained male rowers. *Acta Kinesiologiae Universitatis Tartuensis* 18: 47-55, 2012.

22. Kleshnev, Valery. *The Biomechanics of Rowing*. Marlborough, UK: Crowood Press; 90-91, 2016.

23. Kolumbet, A, Babina, N, Babina, T, Dudorova, L, and Natroshvili, S. Study of the rowing technique major components. *Journal of Physical Education and Sport* 18: 1886-1889, 2018.

24. Kraemer, W, and Fleck, S. *Optimizing Strength Training*. Champaign, IL: Human Kinetics; 1-25, 2007.

25. Lawton, T, Cronin, J, and McGuigan, M. Strength tests for elite rowers: low- or high-repetition? *Journal of Sports Sciences* 32(8): 701-709, 2014.

26. Lockie, R. Circuit strength training with ability-based modifications for law enforcement recruits. *National Strength and Conditioning Association* TSAC Report 51: 26-33, 2019.

27. Penichet-Tomás, A, and Pueo, B. Performance conditional factors in rowing. Factores condicionales de rendimiento en remo. Retos: *Nuevas Perspectivas de Educación Física, Deporte y Recreación* 32: 238-240, 2017.

28. Pollock, C, Jenkyn, T, Jones, I, Ivanova, T, and Garland, S. Electromyography and kinematics of the trunk during rowing in elite female rowers. *Medicine and Science in Sports and Exercise* 41(3): 628-636, 2009.

29. Russell, A, Le Rossignol, P, and Sparrow, W. Prediction of elite schoolboy 2000-m rowing ergometer performance from metabolic, anthropometric and strength variables. *Journal of Sports Sciences* 16(8): 749-754, 1998.

30. Secher, N. Isometric rowing strength of experienced and inexperienced oarsmen. *Medicine and Science in Sports* 7: 280-283, 1975.

31. Šmída, M, Clementis, M, Hamar, D, and Macejková, Y. Relation between maximal anaerobic power output and tests on rowing ergometer. *Acta Facultatis Educationis Physicae Universitatis Comenianae* 57(1): 68-75a, 2017.

32. Smith, M, Standl, M, Berdel, D, VonBerg, A, Bauer, C, Schikowski, T, and Schulz, H. Handgrip strength is associated with improved spirometry in adolescents. *Plos One* 13(4): 1-14, 2018.

33. Swinton, P, Stewart, A, Agouris, J, Keogh, J, and Lloyd, R. A biomechanical analysis of straight and hexagonal barbell deadlifts using submaximal loads. *Journal of Strength and Conditioning Research* 25(7): 2000-2009, 2011.

34. Thornton, J, Vinther, A, Wilson, F, Lebrun, C, Wilkinson, M, Di Ciacca, S, et al. Rowing injuries: An updated review. *Sports Medicine* 47(4): 641-661, 2017.

35. Wilson, F, Gissane, C, and McGregor, A. Ergometer training volume and previous injury predict back pain in rowing; Strategies for injury prevention and rehabilitation. *British Journal of Sports Medicine* 48(21): 1534-1538, 2014.

36. Young, K, Kendall, K, Patterson, K, Pandya, P, Fairman, C, and Smith, S. Rowing performance, body composition, and bone mineral density outcomes in college-level rowers after a season of concurrent training. *International Journal of Sports Physiology and Performance* 9(6): 966-972, 2014.

ABOUT THE AUTHORS

Will Ruth is a former high school rower who returned to the sport with the Western Washington University men's rowing team, coaching there for several years as Strength Coach and Assistant Coach. Ruth moved to Vermont in 2019, and is now a guest coach at the Craftsbury Sculling Center. He is the author of the website RowingStronger.com and the book "Rowing Stronger: Strength Training to Maximize Rowing Performance," a strength training resource for rowers and rowing coaches of all levels.

Blake Gourley is a former collegiate rower who experienced a back injury that ended his rowing career and began his coaching career. He has spent over a decade coaching rowing and strength training for rowers at numerous levels, drawing on his personal experience, education, and internships to help rowers improve performance and reduce risk of injury. Gourley is currently the owner of Movement Evolution Performance Training and RowingStrength.com. He is also the Injury and Performance Management Consultant for the Los Gatos Rowing Club and a board member for the Sports Medicine Certificate at West Valley College.

FIGURE 1. BATWING ROW—START

FIGURE 2. BATWING ROW—FINISH

The batwing row is an exercise for the scapular retractors, depressors, and elbow flexors. The athlete lies prone on an elevated bench with hips, torso, and head supported. The athlete depresses and retracts the scapulae, then flexes at the elbow to draw the dumbbell or kettlebell weights toward the chest until making contact with the chest or bench.

FIGURE 3. X-BAND ROW—START

FIGURE 4. X-BAND ROW—FINISH

The x-band row is an exercise for the scapular retractors, depressors, and elbow flexors. The athlete takes a half-kneeling stance with torso upright and trunk and gluteals braced. The athlete depresses and retracts the scapulae, then flexes at the elbow to draw the suspended bands toward the chest until making contact with the chest.

FIGURE 5. ERG PLANK—RELEASE

FIGURE 6. ERG PLANK—MID

FIGURE 7. ERG PLANK—CATCH

The erg plank is a sport-specific trunk stability exercise performed on the stationary rowing ergometer (erg) with one polyvinyl chloride (PVC) pipe in each hand instead of the rowing machine handle. Throughout the movement, the athlete maintains firm contact between the foot and footplate, and between the bottom of the pipe and the ground. The athlete takes the release position at the end of the propulsive phase of the rowing stroke and engages the abdominal muscles. The athlete then performs a seated hip hinge to the mid-recovery phase. The athlete then moves to the full compression position of the catch to begin the propulsive phase.

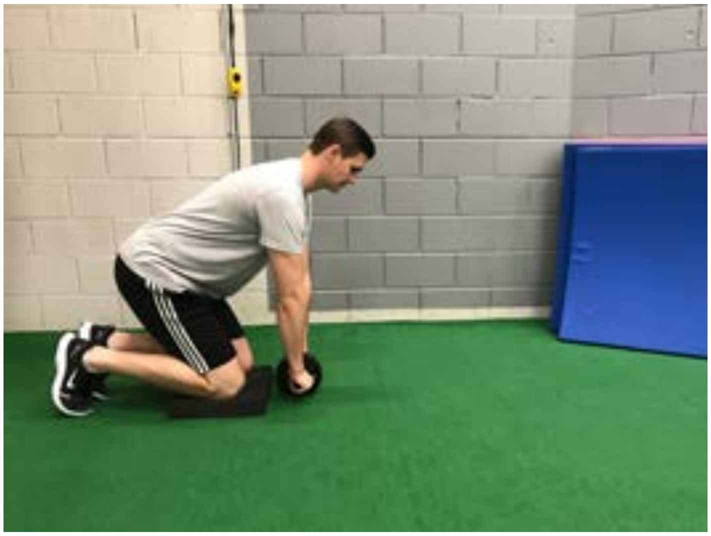

FIGURE 8. AB WHEEL—START

FIGURE 9. AB WHEEL—FINISH

The ab wheel is an exercise for the trunk muscles with movement at the hip joint. The athlete takes a kneeling position and rolls the wheel forward into hip extension and shoulder flexion, while maintaining torso tightness. The athlete then engages the trunk and hip flexors to reverse the movement of the wheel and return to the kneeling position.

FIGURE 10. ELEVATED PUSH-UP—START

FIGURE 11. ELEVATED PUSH-UP—FINISH

The elevated push-up is a modified push-up exercise. It is performed identically to a conventional push-up, but with the hands on an elevated surface. This improves the athlete's mechanical advantage, reducing challenge of the exercise for an athlete whose body weight is too great a percentage of maximum strength.

FIGURE 12. REDUCED-ROM SQUAT—START

FIGURE 13. REDUCED-ROM SQUAT—FINISH

The reduced-ROM squat is a modified squat exercise. It is performed identically to a conventional squat, but with a band in place to reduce ROM. This improves the athlete's mechanical advantage at the bottom position of the exercise, reducing challenge for an athlete whose body weight is too great a percentage of maximum strength or who experiences a mobility restriction at full ROM.

FIGURE 14. ELEVATED DEADLIFT—START

FIGURE 15. ELEVATED DEADLIFT—FINISH

The elevated deadlift is a modified hinge exercise. It is performed identically to a conventional deadlift, but with the barbell elevated on a power rack or on blocks. This improves the athlete's mechanical advantage at the bottom position of the exercise and provides an accommodation for an athlete who is very tall or experiences a mobility restriction at full ROM.

FIGURE 16. BAND-ASSISTED CHIN-UP—START

FIGURE 17. BAND-ASSISTED CHIN-UP—FINISH

The band-assisted chin-up is a modified chin-up exercise. It is performed identically to a conventional chin-up, but with the assistance of a resistance band stretched between the chin-up bar and the athlete's feet or knees. This improves the athlete's mechanical advantage at the bottom position of the lift, reducing challenge for an athlete whose bodyweight is too great a percentage of maximum strength

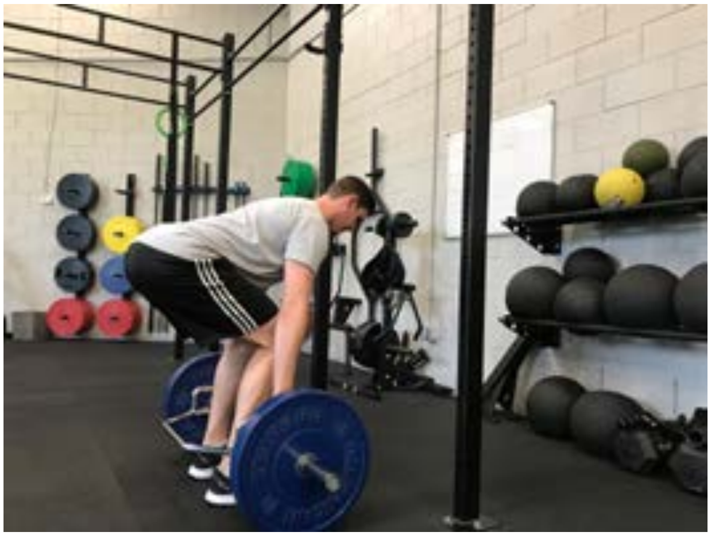

FIGURE 18. HEX BAR DEADLIFT—START

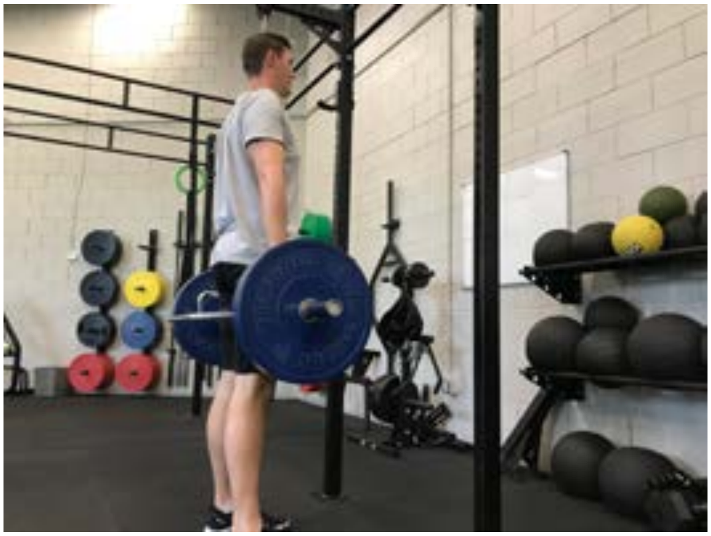

FIGURE 19. HEX BAR DEADLIFT—FINISH

The hex bar deadlift is a neutral-grip, hybrid hinge/squat exercise. The athlete stands in the middle of the hex bar, squats and hinges down to grip the bar, and then stands up to lift the weight. As seen in these figures, some hex bars may have higher handle options that are better suited for taller athletes.

TABLE 1. ALIGNMENT OF ROWING AND STRENGTH TRAINING PERIODIZATION

N. HEMISPHERE SEASON	BLOCK	ROWING FOCUS	STRENGTH FOCUS	BLOCK LENGTH
Summer	General prep	Aerobic endurance and cross-training	Hypertrophy	12 – 16 weeks
Fall	Specific prep	Aerobic endurance	Maximal strength	12 – 16 weeks
Winter	Pre-competitive	Anaerobic fitness	Power	8 – 12 weeks
Spring	Competitive	Race performance	Maintenance and energy management	6 – 12 weeks

TABLE 2. GENERAL PREPARATION BLOCK SAMPLE WEEK

ROWING FOCUS: AEROBIC ENDURANCE AND CROSS-TRAINING					
STRENGTH TRAINING FOCUS: HYPERTROPHY WITH STRENGTH MAINTENANCE					
DAY 1			DAY 2		
Exercise	**Sets x Reps x Intensity**	**Rest Interval**	**Exercise**	**Sets x Reps x Intensity**	**Rest Interval**
A. Hex Bar Deadlift	5 x 5 at 80% 1RM	2 – 3 min	A. Squat	5 x 5 at 80% 1RM	2 – 3 min
B. Vertical Press	3 x 12 at 65% 1RM	1 – 2 min	B. Horizontal Press	3 x 12 at 65% 1RM	1 – 2 min
C1. Unilateral Squat	4 x 10 at 65% 1RM	n/a	C1. Hinge Assistance	4 x 10 at 65% 1RM	n/a
C2. Vertical Pull	4 x 10 at 65% 1RM	1 – 2 min	C2. Horizontal Row	4 x 10 at 65% 1RM	1 – 2 min
D1. Shoulder Assistance	3 x 15	n/a	D1. Shoulder Assistance	3 x 15	n/a
D2. Hinge Assistance	3 x 15	n/a	D2. Hinge Assistance	3 x 15	n/a
D3. Core	3 sets	1 – 2 min	D3. Core	3 sets	1 – 2 min

TABLE 3. SPECIFIC PREPARATION BLOCK SAMPLE WEEK

ROWING FOCUS: AEROBIC ENDURANCE					
STRENGTH TRAINING FOCUS: MAXIMAL STRENGTH WITH HYPERTROPHY MAINTENANCE					
DAY 1			DAY 2		
Exercise	**Sets x Reps x Intensity**	**Rest Interval**	**Exercise**	**Sets x Reps x Intensity**	**Rest Interval**
A. Hex Bar Deadlift	5 x 3 at 85% 1RM	3 – 4 min	A. Squat	5 x 3 at 85% 1RM	3 – 4 min
B. Vertical Press	4 x 6 at 75% 1RM	2 – 3 min	B. Horizontal Press	4 x 6 at 75% 1RM	2 – 3 min
C1. Unilateral Squat	4 x 8 at 65% 1RM	n/a	C1. Hinge Assistance	4 x 8 at 65% 1RM	n/a
C2. Vertical Pull	4 x 8 at 65% 1RM	1 – 2 min	C2. Horizontal Row	4 x 8 at 65% 1RM	1 – 2 min
D1. Shoulder Assistance	4 x 12	n/a	D1. Shoulder Assistance	4 x 12	n/a
D2. Hinge Assistance	4 x 12	n/a	D2. Hinge Assistance	4 x 12	n/a
D3. Core	3 sets	1 – 2 min	D3. Core	3 sets	1 – 2 min

TABLE 4. PRE-COMPETITIVE BLOCK SAMPLE WEEK

ROWING FOCUS: ANAEROBIC FITNESS					
STRENGTH TRAINING FOCUS: POWER WITH STRENGTH/HYPERTROPHY MAINTENANCE					
DAY 1			DAY 2		
Exercise	**Sets x Reps x Intensity**	**Rest Interval**	**Exercise**	**Sets x Reps x Intensity**	**Rest Interval**
A. Hex Bar Deadlift	6 x 3 at 70% 1RM	1 – 2 min	A. Squat	6 x 3 at 70% 1RM	1 – 2 min
B. Vertical Push Press	6 x 3 at 70% 1RM	1 – 2 min	B. Horizontal Press	6 x 4 at 82.5% 1RM	2 – 3 min
C1. Unilateral Squat	5 x 6 at 70% 1RM	n/a	C1. Hinge Assistance	5 x 6 at 70% 1RM	n/a
C2. Vertical Pull	5 x 8 at 65% 1RM	1 – 2 min	C2. Horizontal Row	5 x 8 at 65% 1RM	1 – 2 min
D1. Shoulder Assistance	3 x 12	n/a	D1. Shoulder Assistance	3 x 12	n/a
D2. Hinge Assistance	3 x 12	n/a	D2. Hinge Assistance	3 x 12	n/a
D3. Core	3 sets	1 – 2 min	D3. Core	3 sets	1 – 2 min

TABLE 5. COMPETITIVE BLOCK SAMPLE WEEK (RACE WEEK)

ROWING FOCUS: RACE PERFORMANCE					
STRENGTH TRAINING FOCUS: MAINTENANCE AND ENERGY MANAGEMENT					
DAY 1			DAY 2*		
Exercise	**Sets x Reps x Intensity**	**Rest Interval**	**Exercise**	**Sets x Reps x Intensity**	**Rest Interval**
A. Hex Bar Deadlift	6 x 2 at 75% 1RM	1 – 2 min	A. Squat	3 x 3 at 70% 1RM	1 – 2 min
B. Vertical Push Press	7 x 3 at 70% 1RM	1 – 2 min	B. Horizontal Press	2 x 8 at 82.5% 1RM	2 – 3 min
C1. Unilateral Squat	5 x 6 at 70% 1RM	n/a	C1. Hinge Assistance	2 x 8 at 65% 1RM	n/a
C2. Vertical Pull	5 x 8 at 65% 1RM	1 – 2 min	C2. Horizontal Row	2 x 8 at 65% 1RM	1 – 2 min
D1. Shoulder Assistance	10 – 12 – 15	n/a	D1. Shoulder Assistance	omit	n/a
D2. Hinge Assistance	10 – 12 – 15	n/a	D2. Hinge Assistance	omit	n/a
D3. Core	3 sets	1 – 2 min	D3. Core	omit	n/a

** Note reduced volume on Day 2 for race at end of week*

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STRENGTH TRAINING PRACTICES FOR ROWING—PART 3—CONDITIONING TRAINING

WILL RUTH, MA, CSCS, AND BLAKE GOURLEY, MS, FMS

INTRODUCTION

This is the third and final installment in the series of articles on strength and conditioning training for rowing. The first article presented risk factors for low back pain and rib stress injuries in rowers, and recommended strength training methods to reduce the risk of injury. Strength and conditioning coaches can help rowers improve motor coordination and strength of both stroke motion muscles and non-stroke muscles. Rowers with better movement quality and greater strength will distribute stroke force across many strong muscles, rather than skeletal structures. This reduces excess stress and strain on the spine and rib cage in particular, decreasing risk of injury. Building muscles neglected by the rowing stroke also reduces risk of muscular imbalances. There is also a performance-enhancing effect to reducing injuries. Fewer injuries means more rowers available to practice and more practice opportunities per rower.

The second article covered exercise selection specifically for rowing performance, and periodization strategies to improve strength, power, and muscle hypertrophy. The goal of strength training for rowing performance is to improve general force potential in the major stroke motion muscles. A stronger rower can impart more force on the handle of an oar or rowing machine and maintain submaximal force for longer durations. The most important muscle groups for rowing performance are the leg, hip, trunk, and shoulder extensors, as well as the elbow and forearm flexors. Bilateral power in rowing is sport-specific, and strength and conditioning coaches of rowers should use both bilateral and unilateral squat, deadlift, and horizontal pulling exercises in their training program. A periodized plan provides the organizational framework for the goal of making gradual improvement on multiple beneficial athletic factors over the course of a training year. Strength and conditioning coaches should consider the needs of rowing training, the competitive schedule, the available training time in-season and off-season, and the training experience of the athletes.

This installment will focus on energy system development. It starts with a needs analysis of energy system elements in rowing performance, and then address three key issues in conditioning training of rowers. First, the quantity and mode of training must align with the abilities of the athletes and the major goals of training. Second, strength and conditioning coaches should have a system of periodization to account for changing needs and priorities over a year of rowing training. Third, strength and conditioning coaches should be familiar with best practices for concurrent strength and conditioning training to maximize adaptation to training with minimal risk of interference or injury. This article will conclude with an analysis of opportunities and challenges for strength and conditioning coaches who work with rowers and who may act as advisors to rowing coaches on physical and physiological development.

ENERGY SYSTEM NEEDS ANALYSIS FOR ROWING

Energy system use is mainly determined physiologically by intensity and duration of activity. Because there are several different competitive race distances, duration of activity needs to be carefully defined for individual rowers or teams. This affects energy system profiles, and is important to consider in a needs analysis for an individual rower or team. Masters rowers, adults over age 21, race the one-kilometer distance as their championship competitive event. A one-kilometer race lasts between 3.5 – 5 min, depending on the age category and boat classification. Junior, collegiate, Paralympic, and Olympic rowers focus their training on the two-kilometer race distance. Junior and collegiate crews may achieve this in 6 – 8 min, top collegiate and Olympic crews between 5.5 – 7 min, and para-rowers' times vary between 6.5 – 11 min, based on classification and adaptive equipment used (30). All rowers may also race in distance events of 3.5 km and greater, lasting at least 15 min in duration. It is common for junior, collegiate, and high-performance programs to do occasional distance races as a lower competitive priority.

We will frame our recommendations around the two-kilometer distance, assuming a competitive junior, collegiate, or high-performance program. Researchers indicate that the energy system used in a two-kilometer race is approximately 77 – 88% aerobic and 12 – 23% anaerobic (3,19,23). The variance in these findings exists primarily due to different study populations. Martin and Tomescu studied 16 elite male rowers and found that their energy system use in a two-kilometer ergometer race was 77% aerobic and 23% anaerobic, with an average duration of 6.1 min (19). Pripstein et al. studied 16 competitive female rowers and found that their 2km average time of 7.5 minutes resulted in energy system use of 88% aerobic and 12% anaerobic (23). De Campos Mello et al. studied eight male competitive rowers in two-kilometer tests on static ergometers, dynamic ergometers, and on-water single sculling (3). They found aerobic values of 84% in both ergometer conditions, lasting 6.6 min in duration and 87% in the single scull condition, which lasted 8.5 min in duration. We would expect one-kilometer races to have a greater anaerobic profile and races over two kilometers to have a greater aerobic profile, although no research on this exists (20).

Maximal aerobic power, power output at VO2max, and anaerobic power are significantly correlated with two-kilometer ergometer performance (2,13,24). These correlations illustrate how both aerobic and anaerobic systems contribute significantly to rowing performance. Strength and conditioning coaches of rowers should consider that rowers perform a great amount of aerobic training during routine rowing training. A typical two-hour rowing practice involves a warm-up, a phase of low-intensity technical drills, a phase of continuous effort or interval training, and a cool-down phase. Rowers will also commonly perform more anaerobic training closer to short distance racing, usually consisting of practicing start sequences and short sprints with longer rest periods. The start of the race and the final sprint phase are the phases in the race when anaerobic system contribution is highest (20).

QUANTITY AND QUALITY OF CONDITIONING TRAINING

The first article of this series detailed injury risks resulting from excessive training volume and load on stationary rowing machines, known as ergometers. Researchers indicate that high training volume on ergometers, especially via prolonged continuous use of 30 or more min on static ergometers, is one of the biggest predictors of low back pain in rowers and a significant risk factor in rib stress injury (4,21,29).

There seems to be a tradeoff of performance-enhancing specificity and increased risk of overuse injury from ergometer use and high volume rowing training. Researchers of rowing training practices tend to focus on elite rowers' training 12 – 21 hr per week (5,12,26). Such research is typically concerned with quantifying training methods and comparing models of intensity distribution. There is a research gap of sub-elite rowers and those performing fewer total training hours. Injury data is often not included in training intensity distribution studies and it remains a question if such high volume training methods are appropriate and effective for sub-elite athletes.

High volumes of low-intensity ergometer and rowing training may be appropriate and effective for elite athletes, but may also result in increased injuries from prolonged ergometer use, too high volume or load, or too rapid a progression in volume or load. Athletes who move from one competitive level to the next, such as high school to college, or college to national team, may experience rapid increases without adequate preparation, resulting in injury (20). In "Rowing Faster," rowing strength and conditioning coach Ed McNeely recommends that annual training volume as measured by total training hours should not increase by more than 10% per year and proposes a five-year progressive loading pattern for a junior rower becoming a national team rower (20). Rowing coaches and strength and conditioning coaches should carefully consider the biological age, training age, and competitive level of the athlete to determine appropriate training methods.

PERIODIZED CONDITIONING TRAINING

In the second article, we discussed an annual periodization approach for rowing and strength training. Rowing training typically progresses from off-season higher volume, lower intensity, lower specificity to in-season lower volume, higher intensity, and higher specificity. This model also applies to strength and conditioning training. We suggest that off-season conditioning training for rowers consists of higher volume, lower intensity cross-training, with specific, limited intensity work on ergometers. This develops general aerobic system fitness while mitigating overuse from year-round rowing training and prioritizes energy and recovery for valuable off-season strength training.

Weekly off-season training for a competitive rower might include 1 – 2 short duration sessions, 3 – 5 longer duration, general aerobic development sessions, and 2 – 4 strength training sessions, depending on the needs of individual athletes. For example, a rower seeking greater gains in strength and muscle mass might use four weekly strength training sessions, three aerobic development sessions, and one short duration session. A rower seeking greater gains in fitness might use two weekly strength training sessions, four aerobic development sessions, and two short duration sessions.

We recommend that strength and conditioning coaches avoid additional in-season conditioning training, including any work on ergometers, running, stationary bikes, or other forms of cross-training, unless specifically directed or approved by the rowing coach. Strength and conditioning coaches may have an opportunity for conditioning training with rowers who are injured during racing season. Injured rowers may be unable to row or use ergometers, but may be able to do other productive and pain-free forms of conditioning training to maintain fitness while rehabilitating the injury. Remember that rowers typically do a great amount of aerobic training through sport practice. Anaerobic adaptations are more specific to mode of performance, so in-season rowers should do the majority of their high intensity work on ergometers or in the boat for best carryover to race performance. The limited in-season strength and conditioning contact time is best spent on developing strength, hypertrophy, power, mobility, and energy management or recovery practices. Strength and conditioning coaches may then advise or oversee conditioning training during the non-rowing seasons, using a variety of modalities to improve general aerobic fitness in the absence of rigorous rowing-specific training.

CONCURRENT TRAINING INTERFERENCE IN ROWING

Due to the high demands of aerobic endurance, power, and strength in rowing, rowers must train concurrently for both aerobic endurance and strength. "The interference effect" describes the phenomenon by which concurrent aerobic and strength training may result in diminished adaptation compared to single-mode training (1). Researchers have identified multiple possible mechanisms, and it is likely that a combination of factors and mechanisms produce the interference effect, rather than one single mechanism (1). Researchers have also studied rowers to better understand the specific interactions between concurrent rowing training and strength training (6,7,28,31). In Table 1, we summarize the major findings and proposed strategies from rowing-specific interference effect research.

CHALLENGES AND OPPORTUNITIES FOR THE ROWING STRENGTH AND CONDITIONING COACH

THE ROLE OF THE STRENGTH AND CONDITIONING COACH

The primary role of the strength and conditioning coach is to help rowers improve performance and reduce risk of injury. Strength and conditioning coaches may also have opportunities to inform rowers and coaches on other physical training topics. For example,

TABLE 1. ROWING RESEARCH INTERFERENCE EFFECT FINDINGS AND STRATEGIES

CITATION	SUBJECT POPULATION	MAJOR FINDINGS	PROPOSED STRATEGIES
7	Eight competitive male rowers	Two-kilometer erg is sufficiently aerobic to avoid negative interference from a single strength training session 24 hr prior.	Schedule aerobic training, not anaerobic training, in the 24 hr following a strength training session.
6	28 competitive male rowers	Three low-volume strength training sessions in a single week of training does not negatively affect two-kilometer erg performance.	Rowers should continue strength training during racing season. Use lower volume strength training to reduce risk of interference from muscular endurance training.
28	19 competitive male and female rowers	For eight weeks, rowers strength trained twice per week, did continuous aerobic training three times per week, and aerobic interval training once per week, and significantly improved max force, max power, VO2max, two-kilometer erg performance, and biomechanical technical factors.	Concurrent strength and rowing training can improve physiological factors and biomechanical factors to improve rowing performance.
31	11 National Collegiate Athletic Association (NCAA) Division 1 heavyweight male and female rowers	Rowers strength trained one or two times per week and rowed five times per week. Rowers decreased body fat percentage, increased muscle mass, and improved two-kilometer erg performance over nine months of training.	Athletes may experience significant improvements from concurrent training in body composition and two-kilometer rowing performance, even if diminished compared to single-mode training.

educating rowers on effective strength, mobility, recovery, and breathing strategies. Strength and conditioning coaches should strive to collaborate with rowing coaches to develop a cohesive training program for physical, physiological, technical, and mental development.

Strength training circuits consisting of high repetition (20+), low-load, or bodyweight exercises, are often used in rowing training for muscular endurance or general conditioning training (8). In our experience, this type of training does not develop aerobic or anaerobic fitness as effectively as ergometer training, nor does it develop strength or muscle mass as effectively as traditional strength training. While low-load training may be appropriate for novice trainees or specific phases of a training program, a long-term reliance on low-load, high-repetition training may expose athletes to increased risk of overuse injury and neglect development of greater force capacity. We recommend that strength and conditioning coaches generally limit high-repetition circuit-style training, and advise rowers and rowing coaches on the benefits of higher-load, lower-repetition, more strength- and power-oriented strength training.

ROWING TRAINING CULTURE

Grueling workouts are common in rowing training and experienced rowers tend to have high tolerance to pain and fatigue associated with physical training. Ergometers display performance metrics for every stroke, and rowers are adept at maintaining high force output despite high fatigue. Research on novice and experienced rowers indicates that both groups will sacrifice technique when erging in order to achieve a target output (29). Rowers may carry this mindset over to strength training and struggle to dial down their intensity and drive for very fatiguing workloads. Strength and conditioning coaches have an opportunity to educate rowers on effective strength and movement training, rather than simply encouraging maximal force output or maximal fatigue at all times.

COLLABORATION

Collaboration among coaches is especially important in rowing due to the high fatigue nature of training. We encourage collaboration in training program design to identify specific workouts and general training schedules where fatigue is likely to be very high, or when performance is key. We recommend that strength and conditioning coaches seek to minimize areas of high fatigue overlap. For example, schedule any maximal strength training away from very intensive rowing sessions. Based on the available research on concurrent training practices, we recommend scheduling strength training at least 24 hr before intense rowing training (7). Strength training may be scheduled within 24 hr of rowing training when the rowing training is lower intensity and more aerobic. Be aware that rowers often undergo “seat selection” trials in the weeks before major races, when their practice performance is important to their competitive future. This presents a challenge to strength and conditioning coaches who may want to schedule more intense strength training during this time, before a pre-race taper. Communicate with the rowing coach to establish dates of important ergometer tests, seat selection, and other major rowing events, and develop a collaborative plan to navigate these events. We also recommend that strength and conditioning coaches make occasional visits to rowing practice, if possible. Rowing coaches typically use motor boats for coaching staff, spare rowers, and other observers, and this is an opportunity to watch, listen, and learn about the specific sport training. Observing practice and watching rowers move may also inform strength and conditioning coaches as to the most important "gaps" to fill with a strength training program.

RECOVERY

Research indicate that the intense nature of rowing increases susceptibility to overtraining (17). Strength and conditioning coaches can play a pivotal role by assisting with energy management and recovery practices. For example, educating the team on pre-recovery measures such as sleep, nutrition, and hydration. Research shows that educating athletes on measures such as sleep can improve their sleep quality and quantity (22). Coaches should teach, or assist athletes in monitoring their readiness. Two separate studies concluded that monitoring training readiness may be the best way to help rowers avoid overtraining (15,25). They note that "The Recovery-Stress Questionnaire for Athletes" measures both stress and recovery and may be a helpful, noninvasive strategy to reduce risk of overtraining. In a training session, strength and conditioning coaches can also offer recovery modalities such as breathing, stretching, light movement, compression boots, and cold water immersion. Gill et al. found that recovery methods can be more effective than passive recovery (9). Helping athletes recover during critical phases of training may have a greater impact on performance than adhering to the training session as planned (16).

HEART RATE AS FEEDBACK

Rowing coaches sometimes do not have the opportunity to teach sports transferable skills beyond specific rowing training. Two main skills that can be taught in a weight room are heart rate awareness and breathing strategies. The majority of the time rowers train based on prescribed intensities. Although these intensities are related to a specific heart rate zone, a large majority of rowers do not use heart rate technology. Teaching rowers what each zone feels like can help them understand appropriate intensities in their training. Studies show that rowers and coaches have trouble sticking to prescribed intensities without proper feedback (18). Projecting heart rate on a display screen may help the rower manage intensities based on heart rate feedback. This can be used to maintain the correct target heart rate, as well as educate athletes on the best individual breathing strategies.

BREATHING STRATEGIES

Providing opportunities for rowers to use deep, controlled, and sequenced breathing can help them maintain pressure under challenging scenarios (27). Webster et al. compared three breathing strategies: no breathing strategy, a 1:1, or a 2:1 strategy (28). They found that using a breathing strategy improved performance and other physiological measures when compared to the group that used no breathing strategy. This same study found that utilizing a 1:1 (inhale on the recovery, exhale on the drive) breathing strategy during submaximal training improved the tidal volume for the first half of a two-kilometer race. It increased the volume of air the rowers were able to inhale with each breath. Teaching rowers to use a 1:1 breath during submaximal work, and a 2:1+ breathing strategy during more intense efforts, should benefit their performance. Teaching them deep recovery breaths may also help them relax before performance, easing anxiety, and potentially improving performance (10,14).

CONCLUSION

Rowing coaches are often highly informed on physiological principles and their rowing-specific applications. Strength and conditioning coaches are highly informed on physical training principles, but may lack familiarity with rowing training, technique, and competitive details. Strength and conditioning coaches and rowing coaches have an opportunity to be great allies in the pursuit of rowing performance if their knowledge can be combined. Consistent communication and a genuine interest in collaboration are keys to making this relationship work. We hope that this series of articles helps to inform strength and conditioning coaches on rowing training practices, highlighting specific opportunities where strength and conditioning coaches can have a great impact on the health and performance of rowers.

REFERENCES

1. Coffey, V, and Hawley, J. Concurrent exercise training: Do opposites attract? *The Journal of Physiology* 595(9): 2883-2896, 2017.

2. Cosgrove, M, Wilson, J, Watt, D, and Grant, S. The relationship between selected physiological variables of rowers and rowing performance as determined by a 2000 m ergometer test. *Journal of Sports Sciences* 17: 845-852, 1999.

3. De Campos Mello, F, de Moraes Bertuzzi, R, Grangeiro, P, and Franchini, E. Energy systems contributions in 2,000 m race simulation: A comparison among rowing ergometers and water. *European Journal of Applied Physiology* 107: 615-619, 2009.

4. Evans, G, and Redgrave, A. Great Britain rowing team guideline for diagnosis and management of rib stress injury: Part 1. *British Journal of Sports Medicine* 50: 266-269, 2016.

5. Fiskerstrand, A, and Seiler, S. Training and performance characteristics among Norwegian international rowers 1970-2001. *Scandinavian Journal of Medicine and Science in Sports* 14: 303-310, 2004.

6. Gee, T, Caplan, N, Gibbon, C, Howatson, G, and Thompson, K. Investigating the effects of typical rowing strength training practices on strength and power development and 2,000 m rowing performance. *Journal of Human Kinetics* 50: 167-177, 2016.

7. Gee, T, French, D, Howatson, G, Payton, S, Berger, N, and Thompson, K. Does a bout of strength training affect 2,000 m rowing ergometer performance and rowing-specific maximal power 24 h later? *European Journal of Applied Physiology* 111(11): 2653-2662, 2011.

8. Gee, T, Olsen, P, Berger, N, Golby, J, and Thompson, K. Strength and conditioning practices in rowing. *Journal of Strength and Conditioning Research* 25(3): 668-682, 2011.

9. Gill, N, Beaven, C, and Cook, C. Effectiveness of post-match recovery strategies in rugby players. *British Journal of Sports Medicine* 40(3): 260-263, 2006.

10. Gray, T, Pritchett, R, Pritchett, K, and Burnham, T. Pre-Race Deep-Breathing Improves 50 & 100-yard Swim Performance in Female NCAA Swimmers. *Journal of Swimming Research* 26(1): 32-41, 2018.

11. Greene, A, Sinclair, P, Dickson, M, Colloud, F, and Smith, R. The effect of ergometer design on rowing stroke mechanics. *Scandinavian Journal of Medicine and Science in Sports* 23: 468-477, 2013.

12. Guellich, A, Seiler, S, and Emrich, E. Training methods and intensity distribution of young world-class rowers. *International Journal of Sports Physiology and Performance* 4: 448-460, 2009.

13. Ingham, S, Whyte, G, Jones, K, and Nevill, A. Determinants of 2,000 m rowing ergometer performance in elite rowers. *European Journal of Applied Physiology* 88: 243-246, 2002.

14. Jerath, R, Edry, J, Barnes, V, and Jerath, V. Physiology of long pranayamic breathing: Neural respiratory elements may provide a mechanism that explains how slow deep breathing shifts the autonomic nervous system. *Medical Hypotheses* 67 (3): 566-571, 2006.

15. Jürimäe, J, Purge, P, Mäestu, J, Toivo, J. Heavy Training Stress in Male Rowers: Effects on Circulatory responses and mood state profiles. *Kinesiology* 36(2): 213-219, 2004.

16. Kellmann, M. *Enhancing Recovery: Preventing Underperformance in Athletes*. Champaign, IL: Human Kinetics; 4, 2002

17. Kellmann, M. Preventing overtraining in athletes in high-intensity sports and stress/recovery monitoring. *Scandinavian Journal of Medicine and Science in Sports* 20(2): 95-102, 2010.

18. Lintmeijer, L, Soest, A, Robbers, F, Hofmijster, M, and Beek, P. Real-time feedback on mechanical power output: Facilitating crew rowers' compliance with prescribed training intensity. *International Journal of Sports Physiology and Performance* 14(3): 303-309, 2019.

19. Martin, S, and Tomescu, V. Energy systems efficiency influences the results of 2,000m race simulation among elite rowers. *Clujul Medical* 90(1): 60-65, 2017.

20. McNeely, E. Rowing Physiology. In: Nolte, V (Ed.), *Rowing Faster.* (2nd ed.) Champaign, IL: Human Kinetics; 2011.

21. Newlands, C, Reid, D, and Parmar, P. The prevalence, incidence and severity of low back pain among international-level rowers. *British Journal of Sports Medicine* 49: 951-956, 2015.

22. O'Donnell, S, Driller, M. Sleep-hygiene education improves sleep indices in elite female athletes. *International Journal of Exercise Science* 10(4): 522-530, 2017.

23. Pripstein, L, Rhodes, E, McKenzie, D, and Coutts, K. Aerobic and anaerobic energy during a 2-km race simulation in female rowers. *European Journal of Applied Physiology* 79: 491-494, 1999.

24. Reichman, S, and Zoeller, R. Prediction of 2000m indoor rowing performance using a 30s sprint and maximal oxygen uptake. *Journal of Sports Sciences* 20: 681-687, 2002.

25. Tran, J, Rice, A, Main, L, and Gastin, P. Profiling the training practices and performance of elite rowers. *International Journal of Sports Physiology and Performance* 10(5): 572-580, 2015.

26. Treff, G, Winkert, K, Sareban, M, Steinacker, J, Becker, M, and Sperlich, B. Eleven-week preparation involving polarized intensity distribution is not superior to pyramidal distribution in national elite rowers. *Frontiers in Physiology* 8(515): 1-11, 2017.

27. Webster, A, Penkman, M, Syrotuik, D, Gerbais, P, Cruz, L, and Bell, G. Effect of training combined with different breathing entrainment patterns on physiological adaptations during rowing exercise. *Advances in Exercise & Sports Physiology* 16(1): 15-23, 2010.

28. Webster, T, Gervais, P, and Syrotuik, D. The combined effects of 8-weeks aerobic and resistance training on simulated 2000-meter rowing performance and the related biomechanical and physiological determinants in men and women. *Advances in Exercise and Sports Physiology* 12(4): 135-143, 2006.

29. Wilson, F, Gissane, C, and McGregor, A. Ergometer training volume and previous injury predict back pain in rowing; strategies for injury prevention and rehabilitation. *British Journal of Sports Medicine* 48: 1534-1537, 2014.

30. World Rowing. World best times. Retrieved January 2020 from http://www.worldrowing.com/events/statistics/.

31. Young, K, Kendall, K, Patterson, K, Pandya, P, Fairman, C, and Smith, S. Rowing performance, body composition, and bone mineral density outcomes in college-level rowers after a season of concurrent training. *International Journal of Sports Physiology and Performance* 9: 966-972, 2014.

ABOUT THE AUTHORS

Will Ruth is a former high school rower who returned to the sport with the Western Washington University men's rowing team, coaching there for several years as Strength Coach and Assistant Coach. Ruth moved to Vermont in 2019, and is now a guest coach at the Craftsbury Sculling Center. He is the author of the website RowingStronger.com and the book "Rowing Stronger: Strength Training to Maximize Rowing Performance," a strength training resource for rowers and rowing coaches of all levels.

Blake Gourley is a former collegiate rower who experienced a back injury that ended his rowing career and began his coaching career. He has spent over a decade since coaching rowing and strength training for rowers at numerous levels, drawing on his personal experience, education, and internships to help rowers improve performance and reduce risk of injury. Gourley is currently the owner of Movement Evolution Performance Training and RowingStrength.com. He is also the Injury and Performance Management Consultant for the Los Gatos Rowing Club and a board member for the Sports Medicine Certificate at West Valley College.

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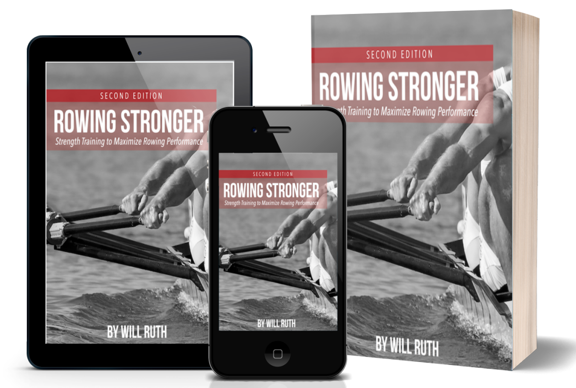

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