STROKEARCS

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ASSOCIATION OF ROWING COACHES, SOUTH AFRICA

INJURIES

Identifying and Treating Musculoskeletal and Nonmusculoskeletal Conditions

In Brief: Rowing – whether on the water or with machines – is increasingly popular, and, as with any strenuous exercise, the potential for injury is high. Rowers may have common symptoms, such as low back and knee pain, or more specific sport problems such as rib stress fractures, nerve impingement, and blisters. Virtually all rowing injuries are due to overuse, and many can be traced to training errors, or equipment problems. Understanding the mechanics of rowing, the equipment, and the training procedures is essential for the physical caring of injured rowing.

Rowing is a port growing both at the competitive and recreational levels. There is also growing enthusiasm for recreational and competitive use of rowing machines, which extend the rowing season and make rowing available to those who have never set a boat on the water. The popularity o rowing means that primary care physicians are increasingly likely to see rowing related injuries.

Demographics

Rowers have been competing at the collegiate and club level for over 10 years. It was one of the first sports added to the modern Olympics and was a popular spectator sport, with significant wagering, in the late 1800's. Today rowing continues at the club, elite, collegiate and high school levels. Recent changes in Title IX enforcement, requiring equal opportunity for participation by women in collegiate sports, has spurred the rapid growth of collegiate rowing for women, with a trickle down effect to the high school level. In the summer Olympics, rowing represents the second largest sport next to track and field in number of participants.

Equipment and Racing

Boat. The rowing boat, or shell, accommodates one to eight rowers, who may have either one oar (sweep rowing), or two oars (sculling). Each station has fixed shoes and a sliding seat. Oars are held in riggers, and multiple individual adjustments are possible to vary the load per stroke, height of oarlocks, and position and angle of oars.

The rowing stroke begins as the oar enters the water, in a position called the "catch". In this position, the legs and back are maximally flexed and the arms extended. During the power phase of the stroke, the "drive" the legs extend, followed by an opening of the back to a less flexed position, and finishing with flexion of the arms, the "finish". The oar is removed from the water and the oar blade is turned parallel to the water by rotating the oar in the fixed oarlock, a maneuvering called "feathering". In the "recovery" phase, the body returns to the catch position, preparing to take another stroke.

Races typically are contested over 1000m to 2000m course in the spring and summer, and 3 miles in the autumn. The spring and summer races are run parallel for up to 6 boats at once, beginning from a stop, and are near maximal aerobic efforts that begin with an anaerobic start and conclude with an anaerobic sprint. Time for the 2000m races vary depending on the boat size and weather conditions but are typically in the 5.5 to 8 minute range. Autumn races are typically from a running start against the clock and are virtually all aerobic effort, typically lasting from 15 to 20 minutes.

Exercise machine. The most commonly used rowing machine, or ergometer, has a flywheel for resistance connected to a handle by a chain, with a retractable stretch cord aiding the return of the handle to the starting position. The rower sits on a movable seat with fixed shoes and pulls the handle away from the flywheel. The ergometer is used for winter training and winter "races" are held in which the times of each participant are compared. It is increasingly common to see people use the ergometer while training for another sport or for general conditioning.

Training

Rowing has both high strength and high aerobic demands, ranking amongst the most strenuous sports. (1) Rowing athletes training virtually all year round, with emphasis on distance training in the fall, weights and distance in the winter, and increasing intensity and anaerobic work in the spring and summer racing seasons. Rowing athletes are highly fit, with recorded VO2 max in the 65 to 70ml/kg/min range for elite athletes (2). Rowing favors the tall athlete with a long reach, who can cover more distance per stroke.

Rowing is a repetitive motion, non impact sport; thus, rowers are unlikely to suffer sudden and unexpected injury, but are likely to suffer overuse injuries. Like other athletes in repetitive sports, the cause of the overuse injuries can usually be traced to a training error in either volume or technique, or inappropriately sized or configured equipment.

Musculoskeletal Injuries

Low back pain. The rowing stroke puts extraordinary pressures on the low back. The back begins the stroke flexed, and during the middle of the stroke the back opens up, but remains flexed, in a motion similar to an uncompleted dead lift. Loading the back in flexion places large forces on both the back muscles and the disks. In one review (3), low back and knee injures were the two most common injuries found in collegiate rowers. In sweep rowing, the back is also twisted slightly during the stroke to achieve more reach in the catch position, which may increase the incidence of back pain (4), though this does not appear to be the case in my experience or that of several US national rowing team physicians.

Back injuries from rowing vary from low back muscle or ligamentous strain to spondolysis to lumbar disk herniation. Physicians evaluating rowers with back pain should maintain suspicion for disk herniation, the most serious of these problems. Rowers sometimes have disk herniation without the typical radiation of symptoms to the legs, perhaps because these herniations represent primarily central disk disease, which does not press on the spinal nerve roots.

Low back pain in rowers usually has insidious onset, typical for an overuse injury, but occasionally rowers may suffer acute disk herniations. A careful history will often reveal training errors, usually from increasing load or distance too rapidly, or attempting a high load drill. The physical examination is frequently unrevealing because the rower may only mildly symptomatic at rest, but a careful search for signs of radiculopathy is warranted. Low back pain, especially with extension in a younger rower, is suggestive of spondylysis, and the mechanism of injury is likely the load to the pars interarticularis from the load to the back in rowing, rather than the repetitive hyperextension mechanisms seen in other sports.

Diagnostic tests are not always indicated at the initial presentation of the rower with lower back pain, but the physician should suspect disk herniation and consider proceeding to lumbar magnetic resonance imaging (MRI) if conservative treatment is unsuccessful. Young people, particularly those with pain in extension, need lain x-rays with oblique views, followed by a bone scan if negative, to rule out spondylysis.

Treatment for lower back pain in rowers is often frustrating, and many young rowing careers have ended because of persistent low back pain symptoms. A typical treatment program of low back strengthening, range of motion exercise, rest as appropriate, and modalities such as ice and external stimulation for pain control is commonly used (5). Rowing equipment can be modified to decrease the load per stroke, and technique can be altered to keep the low back straighter. Having sweep rowers change rowing sides to lean and twist in the opposite direction, unfortunately, rarely improves symptoms. Athletes with disk herniation who do not respond to treatments often have back surgery, which can also end careers. Rowers are cautioned to protect their lower backs by not making errors in training, encouraged to modify rowing technique and volume, and reminded to seek care for persistent back symptoms.

Knee pain. The rowing stroke puts the knee through its full range of motion, with a significant load exerted to the fully flexed knee at the start of the stroke. There is, therefore, a fairly high incidence of pattelofemoral knee pain in rowers. Like patellofemoral pain in other sports, this is more common in women, whose anatomy predisposes them to patellar tracking problems that are further exacerbated by the fixed position of the shoes in the rowing shell. If the shoes are spaced or twisted incorrectly for the individual's anatomy, knee pain ay persist and worsen despite appropriate treatment. Knee pain may also be caused or exacerbated by other activities used for cross training, such as running and weight lifting.

Patellofemoral pain can be treated with specific strengthening of the vastus medialis muscle to improve patellar tracking, and by use of modalities, such as ice, in the acute phase. Bracing of the knee is difficult due to the range of motion required for the rowing stroke and this is not recommended. Modifying the position of the shoes in the boat can have a significant impact by encouraging better positioning of the knee during the rowing stroke.

Rowers may also complain of lateral knee pain, commonly due to friction of the iliotibial band passing over the lateral femoral epicondyl, that is exacerbated by the full knee compression required for the rowing stroke. Individuals with varus knees are at an increased risk for this problem. Again, changing the position of the shoes in the boat can help alleviate symptoms.

Other treatment consists of ice, stretching and other modalities as appropriate. Gradual return to rowing is usually successful.

Rib stress fracture. Stress fractures of the rib were reported infrequently in rowing prior to the introduction of a more efficient oar design in 1992, which was rapidly and widely adopted (6, 7). This new oar holds its position in the water with less slippage, and thus transmits greater force to the muscles of the arm and chest wall. Since 1992, stress fractures of the ribs have been seen at all levels, are regarded by the rowing community as common, and have been reported more commonly in the literature. (8-10)

During the rowing stroke, the serratus anterior muscle hold the scapula firmly against the chest wall while the scapula goes through its range of motion, from protraction when the stroke begins, to retraction when the blade exits the water. Researchers have proposed that overuse of the serratus anterior muscle leads to bending forces at the ribs, which can cause stress fracture, usually posteriorly in ribs 5 through 9. There is a case report (11) of a serratus anterior avulsion from rowing, attesting to the large forces exerted on and by this muscle.

The history of rib stress fracture is one of insidious onset of chest wall pain, often associated with training volume increases or training errors. Athletes often feel this initially as a strain of the intercostals muscles in the chest wall, but over time the pain begins to localize over the ribs, were a palpable bony callus may develop. If a callus is not palpable, diagnosis may be made by plain x-ray, but, in most injuries, a bone scan is necessary for adequate and complete diagnosis.

Unfortunately once the diagnosis of rib stress fracture is made, rest for 6 weeks is usually required for complete healing. There is little else that can be done in terms of physical therapy once the injury occurs; therefore, early recognition is required to save the rowing season for injured athletes. Modifying technique to decrease stress on the serratus muscle, involves decreasing the reach at the beginning of the stroke. It is also possible to modify the equipment to decrease the load per stroke. Specific protraction strengthening exercises for the serratus anterior may strengthen it enough to avoid rib stress fractures, but there is no documentation of the success of such a program.

Forearm tendonitis. Maintaining the tight grip required to hold onto the oar(s) for extended periods of time puts the forearms at risk for overuse injuries. Each rowing stroke also involves twisting the oar parallel to the water when feathering tea or in the recovery stage. This motion is carried out by extension of the wrist, further stressing the forearm.

Rowers with forearm tendonitis typically experience pain, tenderness and even crepitus of the dorsal wrist in the region of cross over between the first and third dorsal wrist compartments. On physical exam, affected athletes have pain and swelling in this region of the dorsal forearm. As with overuse injuries this problem is more common early in the outdoor rowing season when feathering the oar is still and unaccustomed activity. Feathering action at the wrist is not necessary to use a rowing ergometer.

Treatment of forearm tendonitis involves appropriate rest and technique modification. Affected athletes can try to row with their wrists as flat as possible, given their skill level. Looser grip on the oar(s) is also very important. Medical treatment involves ice, nonsteroidal anti-inflammatory drugs, and occasionally, local steroid injection into the tendon sheath. Tendonitis usually resolves quickly with appropriate management.

Dermatological Problems

Hands of rowers are highly susceptible to blisters from friction with the oar handle. Most rowers are reluctant to wear gloves, thinking that this decreases the ability to feel the position of the oar in the water. Rowers in northern climates do not practice outdoors year round, which can result in increased incidence of hand problems when they return to the water each spring.

Treatment and prevention of hand blisters is the object of much folklore and tradition in rowing, but not all interventions have proven benefits. Most rowers merely tolerate blisters as necessary evil that will resolve as the skin adapts. A few may get secondary infections, which often require oral antibiotic treatment. More serious infection is rare. Rowers should be cautioned to watch for secondary infection and taught how to handle calluses to avoid the formation of new blisters under large, thick calluses.

Oars are usually shared among members of rowing teams. Open blisters and hand infections are therefore a potential source of blood or body fluid exposure. Oar handles need to be cleaned regularly, especially after use by an athlete with hand wounds, to limit the spread of infection. One study (12) found an increased incidence of hand warts among members of a rowing team, suggesting that infection may spread even with intact hands.

Some rowers are particularly susceptible to blister, callus and abrasion of the buttocks. This may be worsened by sitting on an improperly fitted rowing seat, which allows chafing or pinching of the buttocks, usually at the finish position of the rowing stroke. Affected individuals are usually uncomfortable but rarely seek medical attention. This problem is usually improved by a different seat, a foam seat pad, and petroleum jelly or other dressing in the affected area. These abrasions can, though rarely, progress to a serious infection and awareness of this problem needs to be increased among rowers to decrease embarrassment in seeking appropriate care.

At the finish of the rowing stroke, the posterior lower leg contacts the metal track in which the seat rolls back and forth as the leg bend and extend. The extent of this contact is variable, depending on the width of the tracks and the height of the tracks relative to the shoes. Athletes who tend to hyperextend their knees, whose shoes are considerably lower than the tracks, or those whose knee alignment also aligns their calves with the seat tracks, can suffer a repetitive abrasion of the posterior legs, known to rowers as “track bites”. These abrasions can be quite severe, frequently scarring and occasionally infecting. Rowers should be encouraged to wear protective long socks, or circumferential tape. Smaller dressings usually do not stay in place. If possible, the equipment can be altered to diminish contact of the legs with the tracks, but this is often difficult or impossible.

Nerve Entrapment

Various nerve entrapments are seen in rowing. They range fro carpal tunnel syndrome caused by tight hand grip to numbness of the legs cased by pressure ion the sciatic nerve from a poorly fitted seat.

A ridge on the front of the seat can place direct pressure on the sciatic nerve. Leg numbness may also occur if the seta holes designed to fit the ischial tuberosities are improperly spaced for the individual, especially when women use seats designed for men that do not accommodate a wider pelvis.

Rowers with carpal tunnel syndrome often hold the handles too tightly and should modify their technique in addition to the usual treatments. Most other nerve entrapments are the result of poor equipment fir, exacerbated by the long rowing sessions. Rowers with nerve entrapment should seek the assistance of an experienced rowing coach or trainer to aid them in making equipment modifications.

Environmental Exposure

Rowing is an outdoor sport; thus, rowers should be aware of exposure and safety issues, including sun exposure augmented by reflection from the water and hypothermia augmented by wet clothing. Water exposure is not intentional, but splash when the oars enter the water frequently reaches rowers, making water quality a potential health problem as well.

Most rowing associated deaths are preventable and due to drowning or exposure. Storms causing lightning and high waves are dangerous for any small boat and should be avoided. Collisions are possible, strict attention must be paid to traffic patterns and use of lights in low light conditions. Rowing solo is not recommended. Rowers should be cautioned to dress appropriately in non cotton layers (depending on the anticipated weather conditions), avoid severe weather conditions that could be life threatening, and carry and use safety equipment such as lights whistles, and personal floatation devices (PFD’s). Caches should ensure that their launches are equipped with safety gear including PFD’s, paddles, lights, and a two way radio or cellular phone.

Key Understanding

Rowing is a popular, strenuous sport with both unique and common injures caused by overuse. Acute, sudden injury is rare. An understanding of the mechanics of the rowing stroke, the equipment, and the training practices is key to making appropriate changes to prevent and treat injury.

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ASSOCIATION OF ROWING COACHES, SOUTH AFRICA

COACHING PERSONALITIES

INTERVIEW WITH MARTIN MCELROY

Q: How did your crew achieve peak performance on the day of the Olympic Final? -Rick from MA

A: It seemed like everything was ready for that day. The equipment was ready, the athletes were ready. We'd always prided ourselves on learning at every opportunity. Over the years we'd learned lessons about training, we'd learned lessons about technique and we'd learned lessons about the mental strength needed to perform at the highest level. For me, the challenge in the olympic environment was mainly psychological. It was about managing the whole experience. It was about doing what we knew in the olympic cauldron. Even in our first race we were still making mistakes. However after that things began to crystallise. From then on a momentum started to build. Two days before the final we did some speed work that was exceptional. We had never gone that fast before.

The day of the final was almost calm by comparison to earlier days. We were on a very early bus to the course. It was still dark as we sat on the bus. The radio was playing and then something that I'll remember for the rest of my life happened. The DJ played a track by AC/DC - 'Back in Black'. This was a heavy rock song that had pounded around the gym at Imperial College during my early coaching days. I looked around at Louis Attrill our four man and also an Imperial alumnus. He'd latched on to it as well. I'm not superstitious but that warmed me up. It just seemed that even at 6am in the morning, halfway around the world on one of the most important days of our lives things were looking good.

All our planning was for this race. The final event of the project was here and it seemed that everything was in place. I suppose that's what preparation is all about. Even four years ago we all knew exactly when and where that race was going to take place. The light would turn green at the appointed time and you were either ready or not.

Q: There was a lot of controversy involving performance-enhancing drug use at the Sydney Olympics (especially in the sport of rowing). What measures do you take to make sure your rowers remain clean? Do you think there are countries that try to cheat the system? -Michelle from VA

A: The testing was rigorous from the moment we arrived in Australia. There were times that I wondered if the athletes would have any blood left to race with! Seriously though, I don't think drug use is endemic in rowing. Rowing is not a big money sport. It's not as if thousands of dollars of prize money is riding on it. Of course individual athletes may feel the desire to cheat and that is more difficult to eliminate. The best we can do is to develop a culture where it is unacceptable, both in terms of peer pressure and through the rules of our sport.

There is a strong anti-drugs culture in sport in the UK. It's probably something to do with the british sense of fair play. There is also a tough regime of testing both in and out of season. Testers can arrive at an athlete's door any time, day or night. It would take so much effort and expense to attempt to buck the system, that I doubt any athlete would find it worthwhile in the UK. That's not to say that it couldn't happen, indeed there have been cases in other sports although they've become tangled up in the debates about contaminated supplement products. The advice from the governing body of rowing in the UK is train correctly, eat well and avoid anything that is of dubious origin. I think the drugs and supplements policy of the governing body is available on their website.

Q: As last year's top eight, I imagine there are lots of crews gunning to knock your crew off of the winner's podium. How've you prepared your crew to handle this pressure? -Roger from FL

A: We will continue to focus on what got us into that position rather than worry about the winner's podium. Keeping focused on the process rather than the outcome is what's important. If we keep working on our process, then the results will start to follow. Remember, it took us 4 years to figure it out the last time. Sure, we have the benefit of experience, but it will be a new crew with new challenges and dynamics.

Q: Is there any frustration from you or the team with the amount of press that Redgrave and the four has gotten? (After all, you guys did win gold in THE top rowing event) -John from VA

A: We always knew the attention would be on Steve and after all it was a pretty remarkable achievement. Steve deserves all the plaudits he can get! We also used the situation to our advantage. With so much attention on Steve before the games it took all the pressure away from us. The eight was very low key pre-olympics. That allowed us to focus on the job in hand. The other thing to remember is that none of the guys were doing this to be famous. They were doing this for themselves. After all, they're a young group of guys. The the thrill and excitement was about going to the olympics, and meeting the challenge. That is what it was all about. The press and media coverage were a bonus after the event. The eight's win did take the imagination of the public, but in a different way to that of the four, precisely because they were a very different group.

Q: I'd like to hear coach McElroy's thoughts on how to move your club/team up to a higher level of competition. Right now it feels like my own team is stuck in a rut, we go to all the same regattas year after year and never seem to be better than middle of the pack. We've had a few fast novice teams but they seem to either quit or fade. How would you go about infusing a team with a sense of purpose and raising their standards of quality and commitment?

A: Not matter what level your club operates at you have to strive for excellence at that level. Analyse the training that you do relative to your competitors. Are you doing a similar number of sessions. How are these distributed in terms of gym and water work. Then make sure the balance is actually right for effective training. On top of this it's worth looking at the lifestyle of your athletes. Can they cope with the demands of the programme and all the other things going on in their lives. Maybe they can do a little bit more! Maybe what they already do needs to be better led.

Treat it like any problem solving activity. Take a look at your resources and how they're utilised. Is it effective? In that analysis include yourself. Do you have all the skills necessary. Are there areas that you could upgrade your knowledge in. If you want to have the best crew at their level then you have to be the best coach at that level. It's not all about having the best equipment and the flashiest gym. What's much more important is what you know and how you apply it.

Success retains people. When people get the winning bug they want more. From my own observation this success is almost always down to the organisation and coaching within a club. I've seen it at so many different levels that

I'm thoroughly convinced these are teh main factors. People competing at club level will do what they're being asked to do. They're attending because they want to do it. They just need the leadership to show them what to do. When they start to reap the rewards they enjoy it even more and the cycle starts to reinforce itself. It's the old adage "success breeds success"!

Q: The Aussies were really charging in the last 500m of the Olympic final. Rumor has it they actually hit the gate at the starting block. Do you know what really happened and does Australia have enough to catch you guys this year? -Ashley W.

A: I've heard that comment about the gate before, but could never see it on the video. Who knows? As for this year, it's a new year. After all, the americans went pretty well in '97,'98,'99. I'm sure they'll be back. I don't know what the priorities will be in other teams this year. The australians, croatians, and don't forget the italians will be there, they were not far behind either. We should also expect to see the germans rebuilding in this cycle. Realistically, there is very little amongst these crews. A single mistake racing at this level is enough to drop you to the back of the field.

Q: I was wondering what process you went through in selecting the boat and oars you used. Was there a lot of testing involved? Did you allow your athletes to participate in this decision, i.e.. their comfort factor? What were your rigging dimensions for your Olympic eight? -Holly from MA

A: As an engineer by training I never take the status quo for granted. In the past crews mainly used empacher boats and concept oars. Was this because they were the best or because everybody was scared to do anything different? I didn't know the answer to that question or even if it was the right question. What I did know was that I'd like to test the hypothesis. It also concerned me that athletes got so hung up about equipment. Very few, if any, crews are constrained by their equipment. The differences due to equipment are so small compared to the impact of how a crew rows or how fit they are. Of course if there's any potential for advantage from equipment then I'd rather have it than not...

So, in the right context I set out to see what I could find with regards to equipment. Boats tend to be evolutions of something earlier. Things get lost in the mists of time. Why is it a particular shape? Just because something else was or because some serious research has been done. If research has been done, then what tools and methodologies were used. Are they correct and up to date? When you start to ask these questions there aren't many who can answer through progressive levels of questions. With regard to boats, Vespoli can answer quite a few questions. Carl Scragg, the naval architect has taken a good look at boats. Overall, I'd be more inclined to go with this than with data that originated in the former GDR. Things have changed a lot since then. Much more powerful computational tools are available...

I've done practical testing before and found the results questionable. Quite often the faster boat is the more uncomfortable. But does there come a point where being uncomfortable inhibits the athlete? As it happens the Vespoli is very comfortable but then most heavyweight boats are. With regard to oars, we used concept smoothies in '97 and then Croker slicks after that. Although I like the idea of adjustable handles, I found the early concept version required a lot of maintenance. I spent two days at the world championships in '97 changing inserts and grips. I didn't think that was the most productive use of my time. The more we used the Crokers the more we liked them. They sat very positively in the water right from the entry. I'm not fixed in my views about oars. Athletes adapt to oar types just as they do to rigging within reason...

We rowed a number of different rigs. In the end our boat was set on a span of 83.5 cm. The oars were 375.5 cm with an inboard of 114 cm. There's nothing drastic about this rig. It might even seem a little on the light side, but then how you row has a major impact. Referring to technique, if you row effectively then a seemingly light rig will feel just as heavy as a heavier rig that's rowed ineffectively. It's important to link rigging to the way you row. I'd advise coaches to use other crews rigging data carefully. It's only part of the picture...

Oh, and I should say that we use ordinary concept oars in our pairs. We've spent periods of the year training in an emapcher eight. My message is that sure, use the best equipment for you needs if you can, but don't be dependent on it. What would happen if your boat falls off the trailer on the way to a regatta and somebody offers you the use of a perfectly good boat, but it's not what you usually use? Do you blame the boat if things don't go well? Seek to make your crews resilient. Develop a flexibility that allows you to focus on what really matters. Currently, we have a culture amongst the eights group that doesn't worry about rigging and equipment. That's not saying it's not looked at, it is, but not as a 'big' issue. I'd much prefer athletes to focus on how they use it.

Q: Does your crew do weight training? What kind of exercises?

A: In the normal pattern of things we train with weights twice a week. During the winter if we're away on a cross training camp we might do more. The exercises are quite straight forward. Bench pulls, bench press, leg work, core stability work. We didn't tend to do high repetitions, mostly 6-8 reps. In the end we're there to row so we want to make sure that our training is specific.

Q: Could you give some tips on determining line-ups? I'm sure it is a much different ball-game at the National level, but perhaps some of your techniques could apply to juniors as well. Also, any thoughts on switching rowers from side-to-side to maintain flexibility in your lineups?

A: There are many views on this topic. At national level, I'd ideally like athletes to be able to row in any seat. The rhythm should be coming from the whole crew. Again at national level you'd expect the boat to feel the same no matter where you sit. This is very difficult to achieve, but is the ideal to which we aspire. As far as sides go, it is an unfortunate situation that most international athletes tend to row one side only. There are exceptions but not many. James Cracknell from our coxless four has changed sides this year to row in a pair with Matthew Pinsent. That was after 12 years of rowing starboard...

Determining line ups is a difficult matter and it's very difficult to be prescriptive. So much comes from the coaches judgement on this one. In developing athletes there are so many factors that can play a role. The more inexperienced or those with slightly less developed skills tend to sit in the middle where they feel stable and have a pattern to follow. In effect, follow is what they do, which does result in a different feel because although the visible timing might be similar, the pressure generated is slightly lagging down the boat. At international level this would be a disadvantage as loadings would be different. At a more developmental level I'd say it it was almost inevitable...

People with relatively stable technique tend to work well towards the stern of the boat, although it often helps to have a stroke who can lift the tempo a bit if necessary. I'm sure I'm not telling you anything new on this one. It's important to trust your judgement, but don't be dogmatic about it, always be prepared to change your view of athletes as their skills improve. The biggest mistake you can make is to label an athlete for a particular seat. On many occasions I've had to develop people into roles that I might not have envisioned previously. Always be prepared to be surprised!

Developing the flexibility to change sides is a tremendous asset. The earlier athletes develop this flexibility, the better. In the UK most juniors start their careers by sculling for about 3 years. Most coaches then try to keep their athletes flexible by rowing on both sides. That generation hasn't yet come to senior level, but the approach has worked well in other countries that have tried it.

Webmaster Note...we have time for about 4 more questions

Q: What style/technique do your rowers use to row so smooth? How do you go about making changes to their technique? -Mike from LA

A: I've worked closely with Harry Mahon, the reknown New Zealander, for the past few years. I've learned some invaluable lessons from Harry. Overall, I'd say our technique is based on simplicity. A stroke has to have reasonable effective length, the power must come on in a sustainable fashion and nothing should be done to slow the boat down.

Our sport is about taking both athlete and boat down the track in the best possible time. The athlete has a finite amount of energy to offer during the race. An effective technique tries to maximise the boat speed that can be generated over this period. Putting the spoon into the water in an effective manner is crucial. This is much more a matter of timing than speed. You see a lot of crews trying to put the spoon in faster and faster which results in a choppy, tense stroke. So, for example in this case some of the athlete's precious energy is diverted away from effective propulsion. Being a closed skill sport every element of the technique influences what follows. An aggressive, tense catch interferes with the athlete's ability to then generate an effective power curve. Problems with how the power is generated affect the release at the finish. Problems here then interfere with the ability to organise the recovery in such a way that the next stroke has the required length, whilst also allowing the boat to move forward easily...

I just started the above example by beginning at the entry. I could have started anywhere in the stroke really. Without trying to categorise out technique relative to others, I'd say we attempt to row in a natural relaxed fashion. We focus a lot on eliminating extras - if it offers nothing to the speed of the boat then why do it? The momentum of the athletes in the crew is crucial.The athletes moving back and forth along the slide can be basis of a rhythm. You can either bang off the footstretcher and pull yourself back up the slide for the next stroke, or you can spring off the stretcher just as a good basketball player would to gain maximum height and then allow the forward moving boat to bring your feet to you before springing again. Of course, the spoon must be used (timed) to harness this momentum. If the spoon is not put into the water before this change of direction then the boat is kicked backwards AND the resultant stroke is shorter as well because some of the athlete's length has been expended before propulsion can begin...

Changing technique is just the same as changing any behaviour - it ain't easy! The learning process is just as applicable here as in any aspect of life and work. The first thing is that the coach must be sure of the model or vision of how to row. It's also worth saying at this point that there are many ways to do it! if you watch international crews row, they don't all row the same. Yet all have their day at some time. Be ccareful about this. If you can't justify it to youself then you'll never sell it to your athletes. Seek to understand why you wish to row in a particular fashion. This may develop and change over time. That's ok! Then when you've got your model and can fully understand it yourself you can start to develop it in the minds of your athletes. Ultimately your athletes will have to perform under tremendous duress. They will be operating right at their limits. It's not like a kicker in football who has to do it once. The rowing athlete has to do it about 200 times with no break over the course of a race. Under this sort of pressure there can be no doubt about how its going to be done. There isn't really time to think about it...

In a racing situation the action has to be automated. It's pretty crucial then that the action is the right one. Adherence to the model is then the next challenge. In the 3 years that I worked in the lead up to Sydney, I'd say that I spent the first year developing and clarifying the model in my own mind and then the next 2 years teaching and clarifying it in the minds of the athletes. For us the whole thing was very process driven. The challenge was always the process not the outcome. Obviously the outcome was pretty important in the final race! By the end there was no doubt about how we intended to row. The athletes and cox developed a tremendous abilty to analyse their rowing...

I've often thought that the challenge for the coach in this situation is being able to stick at it. All through the long training periods it takes a lot of passion and attention to keep working on it. It's very easy to let it slip, to accept something that's less than 100%. The ultimate test has to be at the end. If you can look back and say that there was absolutely nothing more that could have been done then perhaps the other crew was just better on the day. However if your crew wasn't as fit as it should have been or couldn't hold together technically or whatever, then the coach has to start by examining himself/herself. Was what I was doing right, and had the athletes understood and assimilated it to the point where it was their natural mode of operation?

In a practical sense this means taking advantage of every possible opportunity to engender the technique necessary. Use every possible tool and common sense idea that you can find. If that doesn't work, develop some of your own! Remember, what you're trying to do is help the athlete to share your vision. the difference is that they will be in whole world of pain as they're trying to do it. There can be no room for ambiguity.

Q: I have a couple questions regarding the Olympics: How long did the eight row together prior to the Olympics. Was it the same crew from the '99 Worlds? Also, what kind of speed-work did you do the 2 weeks prior to the Olympics?

A: There were 8 of the '99 crew in the sydney crew including the cox. Through the winter the athletes trained as individuals. In the spring they went into pairs and then raced in pairs at the spring trials. From this race and the other tests like ergo tests selections were made to race in the FISA world cup regattas in the eight. Even through this period there were still some changes and only after Lucerne regatta in july was the crew finalised. It was a really tough decision to have to cut someone at this stage. We had a really good group of athletes including four guys who went on to win the coxed four at the world championships. This strength in depth was important to create a competitive training environment.

As for the spped work, we did some 500m and 1000m pieces. We also had some 250m for top speed work. Some of these would be flat out, others were at race pace. Crews at this level can generate speed quite quickly so they don't need to do large amount of speed work. Over the course of the week we wouldn't have done more than four 500m, four 1000m and a few 250m pieces.

Q: OK, last question, and as the Webmaster, I get to ask it. Aside from the countless television interviews, bundles of cash, and athletic apparel endorsements, what sort of recognition have YOU gotten from the local and international media?

A: I wish! As in many similar situations, the coach tends to take a back seat in the media attention. However just as in the case of the athletes, I wasn't doing it for media coverage. Now a few new pairs of training shoes might be a different matter! Perhaps I could endorse a coaches bicycle or something! Seriously though, all the coaches of medal winning sports at sydney were well treated by their peer groups and sports organisations. I've been to Buckingham palace and checked out the queen's pad. A bit big for my liking! I did get an award from the national coaches foundation that puts me in the coaching hall of fame alongside some great coaches from many sports in the UK. That probably means most to me. Recognition from your peers is quite special.

Martin McElroy is currently a High Performance Coach with British International Rowing. Martin coached the Great Britain men’s heavyweight eight that won the gold medal at the Sydney Olympic games. Great Britain last won the gold medal in this event in 1912.

Over the 4 year period of the Sydney Olympiad Martin developed the men’s eight team from being a crew of aspiring young athletes into a tightly knit group whose performance in Sydney excited the whole nation. Having only taken up coaching at Imperial College Boat Club in 1995 and then becoming a full time professional coach with the national team in 1997, Martin has had significant wins at every level of his coaching career.

Martin studied engineering at University College Dublin and after working as an engineering manager for a number of years including a spell working in Africa, Martin returned to university to complete a Masters in Business Administration (M.B.A.) at Imperial College in London. Having rowed himself, Martin became involved in coaching after completing his course at Imperial College.

Martin’s credits this background for much of his success as a coach. Drawing on his engineering, management, and business experience Martin is a methodical coach who develops the athletes and resources necessary to achieve excellence. Being an Irishman, the final element in Martin’s arsenal is a liberal helping of Celtic passion.

Career Highlights

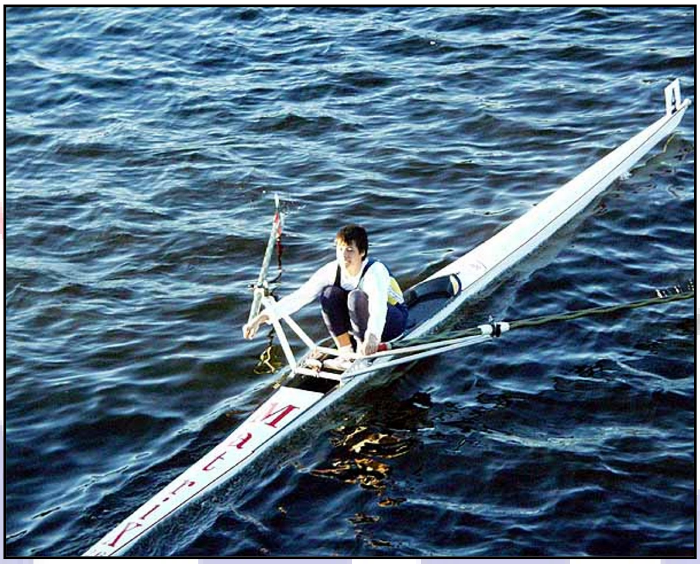
International			
Olympic Games	2000	Men’s Eight	Gold
World Championships	1999	Men’s Eight	Silver
	1998	Men’s Eight	7th
	1997	Men’s Eight	4th
Nations Cup	1996	Men’s 4-	Gold
National			
Henley Royal Regatta	1996	Grand Challenge Cup	
Winners			
	1995	Thames Challenge Cup	
Winners			
Head of the River	2001	Men’s Eight Winners	
	2000	Men’s Eight Winners	
	1999	Men’s Eight Winners	

ASSOCIATION OF ROWING COACHES, SOUTH AFRICA

COACHING PHILOSOPHY

Big Rocks

A while back I was reading about an expert on the subject of time management. One day this expert was speaking to a group of business students and, to drive home a point, used an illustration I'm sure those students will never forget. After I share it with you, you'll never forget it either.



As this man stood in front of the group of high-powered over-achievers he said, "Okay, time for a quiz." Then he pulled out a one-gallon, wide-mouthed mason jar and set it on a table in front of him. Then he produced about a dozen fist-sized rocks and carefully placed them, one at a time, into the jar. When the jar was filled to the top and no more rocks would fit inside, he asked, "Is this jar full?"

Everyone in the class said,

"Yes."

Then he said, "Really?" He reached under the table and pulled out a bucket of gravel. Then he dumped some gravel in and shook the jar causing pieces of gravel to work themselves down into the spaces between the big rocks. Then he smiled and asked the group once more, "Is the jar full?"

By this time the class was onto him. "Probably not," one of them answered.

"Good!" he replied. And he reached under the table and brought out a bucket of sand. He started dumping the sand in and it went into all the spaces left between the rocks and the gravel.

Once more he asked the question, "Is this jar full?" "No!" the class shouted.

Once again he said, "Good!" Then he grabbed a pitcher of water and began to pour it in until the jar was filled to the brim.

Then he looked up at the class and asked, "What is the point of this illustration?"

One eager beaver raised his hand and said, "The point is no matter how full your schedule is, if you try really hard, you can always fit some more things into it!"

"No," the speaker replied, "that's not the point. The truth this illustration teaches us is: If you don't put the big rocks in first, you'll never get them in at all."

The title of this letter is 'The "Big Rocks" of Life'. What are the big rocks in your life? A project that YOU want to accomplish? Time with your loved ones? Your faith, your education, your finances? A cause? Teaching or monitoring others? Remember to put these BIG ROCKS in first or you'll never get them in at all.

So, tonight when you are reflecting on this short story, ask yourself this question: What are the "big rocks" in my life or business? Put those in your jar tomorrow.

ASSOCIATION OF ROWING COACHES, SOUTH AFRICA

FEMALE ATHLETES

Some Relevant Sex Differences, With Reference to Rowers

1.1 Introduction

This section will concentrate mainly on those anatomical and physiological aspects which influence physical performance in dance, physical activity or sport, with a brief introduction to sexual dimorphism, or how we become two sexes. The important point to grasp in any description of such physical differences is that, although on average one sex may have one attribute more highly developed than the other, there is very broad overlap. The average height of British men and women is 5'9" (1.7m) and 5'4" (1.6m) respectively. Yet very many women (e.g. rowers, basketball players) are taller than the male average, and vise versa. And to give a performance example, the best male Marathon runners in the world run the distance in about 2 hours and 6 minutes, and their female counterparts run under 2 hours and 20 minutes. Nevertheless, those elite women runners will beat all but a very small percentage of all male marathoners. In its day, the East German women's athletics team could have beaten the men's teams of many of the smaller nations.

For much of this paper, I am talking about average differences between groups of men and women. It is important to remember that much of the differences between people in general relate to the genetic hand that they are dealt at conception. To take one example, maximal oxygen uptake (VO2 max). If one were to measure this value in the laboratory on a random selection of 100 20-year old untrained but healthy young women who were all the same height and weight, it could be found to vary between 1.5 and 3.5 liters of oxygen used per minute. The reasons for the wide range would be largely genetic. And if one took the lower quarter of the sample, and subjected them to two years of Olympic-style rowing training, they might improve as much as ~25% - say to about 2 liters of oxygen per minute. In other words, even with training, they would not come near to the better genetically endowed upper group. This aspect of genetics is not a fact to get depressed about, especially in an activity needing several attributes such as rowing. It simply means that one has to identify one's strengths, and use them to the full. In the example just quoted, it may very well be those with the low VO2 Max might be at the upper end of the scale in terms of muscle strength and local muscle endurance.

One can alter one's physical aspects very considerably, but always in the context of one's genetic programme – which in physical terms is mediated through anatomy and physiology.

1.2 Gender Formation

Gender aspects as a whole in sport and exercise, embrace genetic, hormonal, anatomical, physiological, psychological and sociological factors. The term 'sexual dimorphism' refers to the two sexes which we grow into, triggered initially by genetic and then hormonal factors operating on a fetus.

Gender is coded for in a specific pair of the 23 human chromosomes. Termed the 'sex chromosomes' they are designated as X and Y. XX codes for women and XY for men. It is important to note that all mammals are basically female unless specifically masculinised (vice versa with birds, in whom the males have the pair of identical sex chromosomes). In humans the sexing process is initiated in the sixth week of fetal life. If the chromosomes are XX, then the female development automatically follows the pre-destined programme; i.e. the outer layer of the two small clumps of cells which form the undifferentiated sex gland or gonad, begin their development into an ovary. A double set of tubules known as the *Mullerian ducts* then form the *fallopian tubes*, uterus and upper vagina.

However, following coded instructions from the male Y-chromosome, the medulla or middle of the undifferentiated gonads is stimulated into becoming the male sex glands or *testes*. Within days, these start to secrete two hormones. The 'male' testosterone promotes growth of another tubular system known as the *Wolffian ducts* to form the male tubing, in the form of the epididymis, vas deferens and ejaculatory duct, all concerned with the passage of semen. The second hormone secreted at this time by the embryonic and still abdominal testes is 'Mullerian inhibitor' which actively inhibits growth of the Mullerian ducts. So, not only is the male tubing actively promoted by one hormone, testosterone, but the embryonic female tubing is actively suppressed by another hormone, the Mullerian inhibitor.

So much for the internal genitalia, what of the external? These in the early embryo consist of two cellular aggregates in the pubic region. If there is no Y-chromosome, then these will form into a vagina and a clitoris respectively. But, if Y-induced testosterone is present, then the would be vagina will heal up, as it were and form the scrotum. And instead of a clitoris, a penis will form. Note that the skin of both the scrotum and the external vagina is similarly pigmented, wrinkled and hairy; also the scrotum has a central line (the 'median raphe'), which is where the original vagina healed over (Money and Erhardt 1971 Sharp 1997).

1.3 Anatomical Aspects

1.3.1 Body Dimensions

The average British woman is 1.6m (5'4") tall, compared to the 1.7m (5'9") for men, but whatever the height of a race or tribe, men are about 7% taller. This applies also virtually throughout the animal kingdom, with the main exception of the spotted hyena, in which the bitches are larger – probably and evolutionary adaptation to the fact that the males have a tendency to cannibalize the pups. Girls may be briefly larger – and stronger – between 10 and 12 years, due to their earlier growth spurt, which occurs just over two years earlier in girls. By around 13, the boys forge ahead on average as their growth spurt carries them up to about 10% beyond the girls in many of the physical dimensions.

1.3.2 Upper Body

Men end up with broader shoulders, longer arms, and narrower hips, both in terms of absolute measures, and relative to body height. The shoulder and arm difference usually leads to men being relatively stronger than women in the upper body compared to the lower, and the longer arms give better biomechanical leverage, which is shown to particular effect in throwing events and racket games, where the terminal velocity of the hand, or the head of the racquet, is the critical factor in determining the speed of missiles leaving either. Longer arms – and broader shoulders – also give men a leverage advantage in rowing and canoeing events.

Many women tend to have more of a "valgus angle" to their arms than men, whereby their arm is not as straight as men's. That is, if the arm is held by the side with palms facing forwards, their lower arm angles away from the body. It is one reason why many women tend to throw objects, such as balls, stones and snowballs 'round arm'. The feature is due to a greater male development of the lateral humeral epicondylar cartilage at the elbow. This cartilage has receptor sites specifically programmed to respond to testosterone at puberty, and acts to straighten out the male arm. A woman with a pronounced valgus or carrying angle, who wishes to become a good javelin thrower, might find herself predisposed to elbow injuries, and the same may apply to a lesser extent in rowing. Of the three main athletic throwing events, shot, javelin and discus, and taking into account the different weights of implements which the two sexes throw, women are furthest behind in the javelin and closest to men in the discus. The latter is what one might expect, given that women's greater spinal flexibility allows more rotation, which is especially important in the discus event.

1.3.3 Lower Body

The broader hips of women, both in absolute measurements in many cases and indeed as a proportion of body height, result from a broader pelvis (due t its cells in turn bearing receptor sites responsive to oestrogen). This leads in general to a woman's femur having to make a greater angle medially (the Q-angle) as it inclines towards her knee, which is the main reason why many untrained women throw their heals out when they run. In athletic clubs, such a running style is modified, if necessary.

However, a more important implication of this greater medial angulation of the femur relates to the angle of force of the powerful quadriceps muscles as they insert onto the patella or kneecap. The bulk of this muscle group is located laterally, i.e. on the outer side of the thigh. Thus when it contracts it exerts a strong 'bowstring' effect on the patella tending to pull it sideways (known as 'sub-laxation'), out of the intercondylar groove on the femur in which it normally tracks. This misalignment may lead to excessive wear in the cartilage underside of the patella (the retro-patellar cartilage), resulting in the aching condition of '*chondromalacia patellae*'. Although often known as 'runner's knee', it may occur in rowers, and it is more common in broader hipped women.

This may also tend to happen in women with a tendency to 'knock knees' who have too large a 'Q-angle', which is measured as follows: if you draw a line from the anterior supra-iliac spine (the front of your hip bone) to the centre of your patella, and another one from the centre of your patella to your 'tibial tuberocity' (the bony bump just below your knee), the angle between these two lines make with each other id the Q-angle. In men it should be less than 10degrees and in women less than 15 degrees. If it is greater than these, this creates increases the mechanical advantage of the outside quads, as mentioned above, and it lessens the ability of the one inner quadriceps to counter the bowstring force – the vastus medialis. Thus, overlarge Q-angles lead to bad patellar alignment and tracking in the groove, and increase the possibility of patellar sub-luxation and of chondromalacia patellae. So, ideally a women rower should have, proportionally reasonably narrow hips, and fairly straight legs.

The vastus medialis just mentioned is one member of the quadriceps muscle group, which inserts into the patella from the opposite direction – medially rather than laterally. And it acts to stabilize the patella in its groove, and to counter the bowstring effect to some extent. If you put your hand on the inner side of your knee, and slowly straighten your leg into full extension, then you will fee the vastus medialis tensing up as it comes into action just before full extension. Thus, exercises to strengthen the medialis must always involve straightening the leg fully, and slowly, so that there is no swing effect initiated by the other quadriceps muscles. Straightening the leg while seated, and holding it hard isometrically (i.e. tensed but not moving) will also strengthen medialis. This should be done 5 times on each side, and held for 10-15 seconds, two or three times daily. Otherwise a visit to the 'quads station' of a multigym will provide effective training.

1.3.4 Body Fat

Young women have a considerably greater percentage of their body fat, compared to men. Expressing body fat as a percentage is not especially reliable, but can be a useful rough guide. In my laboratories at the BOMC and elsewhere, the leanest subjects we have measured, mainly elite distance runners and gymnasts, have been in the range of from 5-8% for men, with very few equivalent women below 16%, and ranging up to 21% (compared to a normal student population of between 12-18% for men, and 22-30% for women). Until the age of around 10, there is little difference in body fat between boys and girls, but when both sexes go through puberty, the boys tend to lower their fat percentage, and the girls tend to gain fat. The gain in the women is a natural hormonally induced part of the growth process. The difference in body fat between the 'average' young man and woman is in the order of 70 000 kilocalories (or 300 000 kilojoules), which is just about the energy cost of producing a full term human infant. Rowers tend to vary from 18-25% for heavyweight women, with some lightweights being lower. The men tend to range from 10-15% again with some lightweights being lower.

Body fat is primarily an energy store. And men and women tend to store their fat differently. In men, the main fat store is in the abdomen, so a fat man will have a varying degree of 'beer belly', even though he may have quite slim legs. For women the fat deposits are thighs, hips, bust and back of the arm. It makes sense for women not to store fat on their abdomen, which becomes full during pregnancy.

This gender difference in average body fat certainly aids survival in extremes of cold and starvation, indeed Scott of the Antarctic may well have reached the South Pole had he and the team been women. It often leads to better performance by women in long distance sea, lake and loch swims, in many of which women hold the all-comers records. In part this is because the greater amount of fat acts as an insulation under the skin, and in part it floats women higher in the water, as fat is lighter than water. (Drop a piece of lean meat and a piece of fat – such as butter – in water; and see which sinks and which floats!). Floating higher makes for easier swimming. However the greater fat is a handicap in weight bearing activities involving running or jumping. This is one of several pressures towards a degree of female leanness, as in lightweight rowing, which may be very harmful if taken to extremes. In rowing and canoeing, extra weight lowers the racing shell, and will increase its surface area, and hence friction. Nevertheless, the 'weight-supported' rower can afford to carry an extra kg or two of fat, compared to the runner of gymnast! In women, this may help to minimize or delay the onset of sports osteoporosis – which is seen more in lightweight rowers, as is the associated amenorrhea, or absence of periods.

The gender difference in body shape, much of it accounted for by body fat distribution, leads to many women having a lower centre of gravity, and may be part of the reason for their better balance – as seen on the balance beam in gymnastics, a discipline for women but not for men, and possible shown in sailing, where women crew members are often noted as being better balanced in their movements around the boat.

A certain degree of fat is essential to the body; partly this is in terms of acting as a packing material around vital organs, the ovaries for example, and for helping keep the eye firmly in its socket. Also, fat is important in hormone-processing. It is thought that one reason why women who are very thin stop menstruating is that they do not have enough fat t activate their osterogen precursors.

1.3.5 Flexibility

Women have greater flexibility than men, as may be seen in asking a group of untrained men and women to planter flex their foot, i.e. 'point their toe'. This enhanced flexibility, is of course, much featured in gymnastics and many forms of dance (and in modern circuses e.g. Chinese National Circus, and the 'Cirque du Soleil'). In part the flexibility of women is due to slight differences in their joints, and in part it may be due to the presence of the hormone 'relaxin', which appears to act on the ground substance of collagen, the vital structural element in ligaments and tendon, imparting a greater degree of elasticity. Relaxin comes into its own during childbirth, when it has a major function in acting on the *symphasis pubis joint*. This is where the two pubic bones meet each other at the bony floor of the pelvis – between the legs. Normally there is very little space between the two pubic bones, nor do they normally move, but under the influence of relaxin, the connecting collagen may allow a considerable widening between the pubic bones, thus enlarging the birth canal. The main application in rowing is hamstring flexibility, which may be associated with low back pain injury if the hamstrings are too inflexible.

1.4 Physiological Aspects

1.4.1 Heart, Lungs and Blood – the Cardio-Respiratory System

Women have proportionally less blood (65ml/kg bodyweight compared to 75ml) than men, and lower hemoglobin concentration (13.9g/100ml compared to 15.8g). Working maximally aerobically, women need 7 liters of blood to carry a liter of oxygen, compared to men's 6 liters, yet proportionally their hearts are about 8% smaller, although maximum heart rates are the same. The net effect is on the maximal oxygen uptake, which at elite rowing levels is up to ~75ml/kg bodyweight for men, and ~65ml for women. It is this VO2 Max which is responsible for 'aerobic fitness' or overall stamina – the ability to train on land or water for one to two hours – or more. The other important aerobic aspect is the anaerobic threshold, which is the rate of work which a rower can sustain without incurring a sudden marked rise in blood lactic acid. This threshold indicates the rate of work which can be sustained for relatively long periods. The anaerobic threshold is usually accompanied by a heart rate within a set range, so can be used as a training guide. The overall aerobic sex difference matters little, in that women rowers do not compete with men.

1.4.2 Muscle

Between 10 and 11, many girls are stronger than their boy peers, but boys end up on average stronger. This is partly because the cross sectional area of their muscles is greater, through androgen hormone effects, among other factors – and partly due to the longer levers of their limb bones. There is little difference in muscle quality between the sexes; both tend to generate about 30 Newton's of force per square cm of untrained muscle tissue. 30 Newton's is a force of about 3kg per square cm.

In terms of muscle endurance, women appear to have better low-grade local muscle endurance, for example on repetitions of 50% of their maximum muscle force. This may be of benefit in sports such as swimming, cycling and indeed rowing, which consist of very large numbers of relatively low-grade contractions. And each is a sport where women approach closer to men's performances than weight bearing sports such as running –where the force at each stride are much greater. Although not all related to rowing, it is of interest to briefly note that women have much better fine manipulative skills, e.g. as in keyboards, or electronic assembly.

1.4.3 Heat Regulation

Exercise such as rowing generates considerable heat. About two-thirds of food energy appears unavoidably as heat in muscular work, and this must be lost almost as fast as it is generated, or collapse from heat stroke would occur. We live closer to heat death than to cold death. Normal core body temperature is around 37 degrees, but much above 43 degrees may be quickly fatal. To lose heat in exercise, men tend to sweat more per square meter of skin surface than women (e.g. 800ml/hour/m2 compared to 600ml/hour/m2). However, women tend to loose more heat by radiation. This benefits women in very humid conditions, where sweat cannot evaporate very readily into air already saturated with water vapor. Under such conditions, and not being so reliant on sweating, women tend to radiate more of their heat away, through a warm skin, red with dilated blood vessels radiating the heat away like tiny electric fires.. Men benefit in dry heat, as their sweat can be evaporated. Sweat which drops of is simply wasted, as far as cooling is concerned, because it is when the sweat changes from liquid into water vapor (i.e. steam), that the heat energy is taken form the skin, or, more accurately, from the warm blood circulating through the skin.

So, women thermo regulate better in wet heat, and men better in dry heat. Men will tend to be more severely affected on a hot humid course, and women on a hot dry one. In life threatening environments, however, their greater sweat production implies that mend tend to die quicker than women from dehydration, for example in desert conditions, or if shipwrecked in mid ocean (and having to 'take to the boats' for too long). In both sexes, sweat patterns change through exercise and training, covering more extensive areas of skin, and occurring sooner. It seems surprising, that fit people sweat sooner, as dancers or athletes notice at parties or receptions. In both sexes the level of salts (or electrolytes) in sweat drop markedly, the higher the fitness levels. In other words the fitter you are, the better you conserve your body salts.

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