

STROKEARCS

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SOUTH AFRICA

SELECTIONS

FOUR EASY STEPS TO A SENSIBLE SELECTION PROCESS

This is an excerpt from a larger document dealing with selection for the Canadian Teams for Olympics, Commonwealth Games, World Cups, World Champs etc

Preparing selection criteria is not an easy task, and therefore should be an ongoing process within any sports organization. We would like to suggest a four (4) step process to help you develop a fair selection policy. The four steps are: Background and Research; Development; Validation; Communication and Implementation. For each step, we propose a list of factors that should absolutely be kept in mind (The Musts) as well as a list of practical ideas to guide you through the process (Best Practices). We believe that following these steps will reduce the risks of disputes arising from the selection process. Remember, these are suggestions, it is up to you to decide whether to use any or all of them.

Step 1 – Background and Research

This step allows you to canvass the performance criteria and other conditions that will be applied to your athletes by other organizations. Other conditions may include restrictions that are not linked to performance, from age categories to time limits for registering the athletes. Time is a major component of the selection process. It is therefore crucial to keep certain deadlines in mind in order to achieve your objectives.

THE MUSTS

- Identify the organizations that have authority in admitting an athlete to the competition in question (e.g. the international federation, the competition organizing committee, an international or national Multisport organization, etc.) and obtain the document(s) outlining the conditions for admission.
- Identify the time limits imposed by these organizations. For example, these can be the deadline for registering with the event's organizing committee; the qualification deadlines of your international federation in accordance with established criteria; and in some cases, internal and external appeal deadlines for team members.
- Identify the conditions that are unrelated to performance that define what group of athletes will be admissible according to these organizations (e.g. citizenship status, age groups, weight categories, membership status, etc.) These conditions may come with a time limit as well. For example, the athlete must be born after such date, or be a registered member in due form on such date.
- Identify the minimum performance criteria that will be imposed on all athletes in order for them to be

eligible to participate in the event. These should become the minimum at which you base your own criteria.

BEST PRACTICES

- Based on the time limits imposed for registering your athletes, define precisely the "qualifying period", or the timeframe during which athletes will be evaluated.
- This period should end early enough before the registration deadline to allow appeals to be conducted in a fair manner. It should also give athletes sufficient time to prepare properly and, if required, travel to the competition.

Step 2 – Development

This step is the responsibility of the experts, the coaches and high performance staff, within your organization. They are in the best position to determine WHEN and HOW your athletes should be evaluated in order to decide WHO should be selected. The technical knowledge and expertise they have must now find its way onto paper in a clear and concise manner.

THE MUSTS

- Take into consideration at all times the selection criteria and conditions that are imposed on your athletes by other organizations such as determined in Step 1.
- Ensure that the team responsible for preparing the selection criteria has the recognized authority for this task under the regulations of your organization.
- Ensure that the selection policy is respectful of other applicable agreements or policies that your organization may have adopted, such as its appeal policy, athletes' agreements, etc.

BEST PRACTICES

a) Process

Define the objectives you wish to attain through your selection criteria, such as the pursuit of excellence, team cohesiveness or athlete development.

- Along with a good representation of coaches, administrators and officials, invite athletes targeted by the pending selection criteria to provide you with their input, as applicable.
- Investigate previous errors and sticking points in team selection criteria to ensure they are not repeated; analyze past experiences of your organization to understand which methods work well and which to avoid; consult the lessons learned from team selection cases in the SDRCC Jurisprudence database.

b) Technical Content

- To the extent possible, try to establish selection criteria that is objective to prevent potential perception of unfairness (e.g.: results in certain competitions or events, ranking, scores, statistics and other performance measurements commonly used in your sport).

- If it is unrealistic to base yourselves on objective criteria only, clearly determine the subjective factors that will be considered when the selection is made, such as skills or the athletes' contribution to the team, and propose an evaluation grid to allow for as detailed an analysis as possible of the established criteria.
- Of greatest importance is that the final choice not be random, negligent, arbitrary, or made out of favouritism.
- When looking at potential qualifying events during the qualifying period, you may consider multiple events or a single event. Either way, you should be able to weigh the advantages and disadvantages of opting for qualification through multiple events or for a single qualifying event.

Notable Observation About...

Single Qualifying Event:

- They are usually simple to conduct, however one bad day for your best athlete may mean that he or she is not going to the Games;
- Strong candidates may be injured at the time of the single qualifying event thereby excluding them from the Games, even though they may recover on time for the Games;
- Choosing a qualifying event too close to the Games will require your best athletes to peak twice in a short period of time;
- To hold your event too early before the Games carries the risk of athletes' relative performances changing by the time the Games come along.



Multiple Qualifying Events:

- They are likely to help you select athletes who are consistent in their performance over a certain period of time, but it also make the entire process a lot more complicated;
- It may be more costly for athletes when they have to fund their own participation in the various qualifying events;
- Admissibility criteria to those competitions should be similar to those of the Games so that you do not exclude potential athletes from qualifying; may require weighing the results of the various competitions to reflect differences in field size and quality, or to give more value to events held towards the end of the qualifying period.

Use foresight, and establish steps to follow should exceptional circumstances present themselves (e.g.: injury outside of competition, injury during a qualifying event, faulty equipment, unexpected illness, disqualification of another athlete due to a doping infraction, etc.).

- If your criteria may lead to athletes tying determine in advance on the basis of what criterion or criteria such a tie would be broken; make sure that this criterion is precise enough that it cannot lead to another tie.

c) Administrative Content

- Decide who will be responsible for applying the criteria. We suggest that it would be prudent to assign more than one person to this task, for example a selection committee, in this way you may prevent possible conflicts of interest and other issues related to unfairness.
- Establish in advance the parameters and procedures that will be followed should amendments to the selection criteria become necessary after the criteria have been adopted. A sound communication plan for this will be in order as is highlighted in the fourth step.
 - Amendments are common, but they should take certain factors into account, such as possible disruption of athletes' preparation, the impact these changes have on the current status of athletes in the selection process, etc. The amendments should take into consideration the time that has passed since the adoption of the selection criteria and the time remaining to the qualification period. Ensure that your athletes have a fair chance to reach their objectives and that your amendments do not create any injustices.
 - Determine how and when athletes will be advised of the candidates selected. Again, keep in mind that the date chosen must provide athletes time to appeal, if they so choose and should therefore include an appeal deadline, as appropriate.
 - Plan an appeal process specific to this criteria or refer to your general appeal policy, if applicable.

Step 3 – Validation

Once a draft policy is complete, it is essential to evaluate it. We really can learn from past experience. Do not hesitate to use your human and statistical resources to validate or change your draft selection criteria.

BEST PRACTICES

- Test your criteria against performance results from previous years and look at what would have happened had this selection policy been in place. Would it have yielded the best team possible?
- Test your criteria by asking a neutral but experienced person in the domain to evaluate them. This person can be a former athlete, coach or technical director in your sport. He or she could also have experience in a different sport, such as one that uses similar competition formats or scoring/ranking schemes. What is important is

that the individual have no vested interest in your selection criteria in order to review the criteria objectively and constructively.

Once the selection criteria have been drafted, communicate them to your athletes, and allow them to comment on what you are preparing to adopt; after all, they will be the ones who will have to understand what is expected of them in order to make the team. If your criteria and process are clearly laid out and understandable from an athlete's perspective, you will reduce the risks of disputes later on.

- Compile the comments received and, if you judge it appropriate given the circumstances, provide a formal response (in writing or in person) to the individuals whose suggestions were not retained. Let these individuals know of the attention given to their recommendations, and explain why they were not included.

Step 4 – Communication and Implementation

This step is one of the most important in your process. There is no value to having the perfect selection policy if your athletes don't know about it and therefore cannot apply it correctly. It is also the step from which many disputes emerge.

Communicating your criteria to athletes is one of the keys to your success. Spare no effort!

THE MUSTS

- Translate your documents to ensure that they are in both official languages (English and French). Be wary of cheap translators. They may save you a few dollars at that stage, but a badly translated selection policy increases the risks of the criteria being misunderstood, misapplied, or simply yielding different results than intended.
- Prepare an effective communication plan to reach all of the athletes affected by your selection criteria; a plan that goes beyond simply posting it on your website. Go down your hierarchy one step below the level that you think is targeted by the policy. You never know when an athlete will surprise you!
- Clearly advise your athletes of any changes made to the initial criteria by phone, in person, via emails, etc... Obtain confirmation that they have received your advice and understand its content. Post changes clearly on your website.
- Apply the selection criteria as intended and as communicated.

BEST PRACTICES

- Use all methods of communication judged pertinent: website postings, mailings, faxes, emails, meetings during training camp, annual

general meeting or other meetings, telephone calls; Involve your athlete representative and coaches in the communication process; they can help you find the best channels to transmit information to targeted athletes.

- Prepare a guide or quick reference document containing highlights of the policy (e.g.: mandatory training camps and qualifying competitions).
- Have all athletes potentially affected by this selection policy sign a document confirming that they have read, understood, and agreed with the criteria and the process. This will be an incentive for athletes to actually read the policy!

Allow them to contact a designated resource person (like a coach or a high performance director) to ask questions and clarifications if they are unsure of what the criteria mean. Be sure to keep a record of any interpretation and ensure consistency in the answers provided. If one element of your policy appears to generate many questions, do not hesitate to publish an addendum to clarify its meaning.



- Once your team has been announced according to the established rules, athletes who were not selected may want to learn the reasons for this without having to file a formal appeal. You may provide them with the opportunity to understand the selection process that took place and how best to succeed the next time. Do not hesitate to plan a meeting or discussion with these athletes and let them know that, while they were not selected, they are important to your organization and were considered.

Conclusions

In short, the responsibility of the NSO is to establish a selection process that is as simple and precise as possible and to ensure that its athletes (and other team members) are evaluated in a uniform and fair manner, to avoid any possible conflicts of interest. Widely communicate the criteria and any changes in as many ways as possible; this will prevent misunderstandings, or worse, disputes that will have to be resolved by the SDRCC.

Writing and publishing a well thought out selection policy long in advance of the start of the selection process will inspire trust and confidence among the athletes. Never underestimate the power of consultation and collaboration in order to get buy in.



SUCCESSFUL SYSTEMS

HAROLD JARLING – HOW THE GOLD MEDALS WERE WON

Harald Jarling

Rowing Australia Head Coach for Women since Feb 2001
 NSWIS Head Coach since 1991
 Olympic Coach 1996 (LW2x – Bronze and M2- Silver)
 Olympic Coach 2000 (LW2x – 4th)

2001 Results

I do not want to talk too much about all the details of how fast we were going compared to the rest of the world but really talk more about how we actually achieved what we got from where Women's Rowing was when we started at the beginning of the year. The excellent results for Women in 2001 when you look at detail have been achieved in a very short time but there were still areas to be done better i.e. crews not making A final when it is in the Selection Policy that crews must achieve this level to be selected.

The future looks good in this regard because crews that came 4th all had good chances of coming 3rd rather than 5th and even though it will be hard to do better than the 6 Gold Medals I think we will do better in 2002. It is difficult to predict which colour medals as the difference in winning Gold, Silver or Bronze are quite small margins (point of a second) as you can see in the W8+ race when



all the crews were closing in at the end.

Australian Analysis

When I started the job in February I started with an analysis of the situation in Australia and overseas. To do this in Australia was easy because I have been part of it in

the last 10 years – despite the fact that we had some good female rowers on the water and some good programs running everywhere in the country, there was:

1. A lack of total numbers of good rowers
2. A lack of overall structure so everyone was doing their own thing with technique/training which resulted in not being able to bring together a large number of women together to perform as a team.

I strongly believe that this was one of our shortfalls and we had never really managed to work together as a group of people (coach, administrators, athletes) to be overall successful.

Overseas Analysis

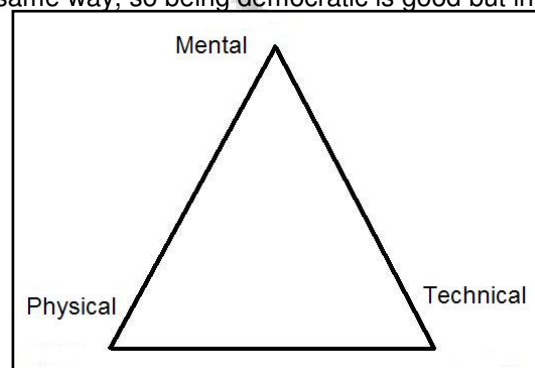
When you look at analyzing overseas programs it is very easy to fall into the trap of looking at one successful crew and saying I want to do this. i.e. Pinsent but athletes do not grow on trees and it is better to look at successful program which have worked with more average athletes. What are outstanding at the moment are the Romanian women crews and the German women Scullers who have the most impressive rowing program in the world. It is important to look not only at their rowing, but also how they get their athletes, what they do in preparing their athletes, what structure they have in their program to succeed year after year, and not only outstanding athletes but average athletes having outstanding performances.

Need Team With Strong Leadership

After this thorough analysis was all about developing long, medium, and short term strategies and then started speaking to the rowers, coaches, and administrators. With the programs in place then I started to meet with all involved so that the female rowing program could be brought to a higher level. I tried to provide strong leadership right from the start so we could pull everyone together in trying to achieve the goals as a team. Not as a dictator but as a specialist in the field of rowing and try to provide as much specific information to the coaches, the rowers and the administrators involved.

I try to lead the process from the top, and I believe any successful company or sports program in the world is running the same way, so being democratic is good but in many instances doesn't work.

Strong leadership needed in order to get.



Setting Goals

In order to be successful need to know benchmarks and set them for all short, medium and long term. Because you are working as individuals, and each is different, you must also set individual goals that are achievable and then the overall goal structure will be determined based on what they are capable of in the short medium and long term. This means monitoring the process of each

individual (training, technical, and mental development) and of the overall program.

I though it was very important early in the process to find coaches and support staff (sport scientist, doctors, physio's, and masseurs) that wanted to work with the program and myself as leader.

Rowing Performance

We look at the current rowing performance of our athletes and basically we aim to improve the corners of the MENTAL-PHYSICAL-TECHNICAL triangle. Everyone has probably seen this before in developing sport performance and if the triangle is made really big you have a chance to get on the podium to win the medals. If the triangle gets one sided or really flat then the chances will be smaller and smaller and I think that anyone in world rowing who is getting medals has no serious deficiencies in any of the three areas.

Mental Development

1. When we started our program we tried to change the attitude of our rowers. Tried to make them more confident and part of a team and teach them about the orientation of the process of being a world champion rather than the outcome of just a dream of becoming a world champion.
2. I believe that confidence comes from winning good races; if you go out there and win and you get confidence, if you go out there and get your backside kicked then you will not have confidence; No matter how confident we talk as coaches if the rowers go out and sit on the start line and they get the shivers surely they will be beaten; we showed the girls how the process works and how confidence starts building...the girls started getting good results in the domestic season (high % in regattas so that increased boat speed being achieved) and then we targeted a race that we thought we could win so the W8+ at Henley Regatta. As the smaller goals were fulfilled then the confidence started building.
3. There is no point in developing individuals who cannot put their individual ideas under the team umbrella – we stressed that right from Day 1 that we are not in a sport where we are there to help every individual fulfill their individual needs and desires; and we try to put that into a square which means the performance of the big boat; in a sport where we have also single Scullers that may be wrong but in the initial analysis we realized that we do not have a single sculler at the moment; the smallest boat that we can boat is the double and pair and from then on the boats can only be fours, quads and eights so that need people with team ideas: I feel that this was the biggest shortfall of

the eights and quads from the last years with some people in the room who would relate to that. We always had fights within the group and then there was always so pecking order achieved straight away, possibly some bitching going on and always individual egos trying to be recognized than under the tam umbrella and pulling on one string. In 2001, in all areas of Senior A, Under 23 and Junior, the group has started to act like a team. There has been some interaction between the age categories, some fantastic interaction between crews in each team and some very good team spirit in the big boats and that actually leads to going there and getting a good result.

4. We talked a lot about what we wanted to achieve in women's rowing, about the result. And we always say okay well we want to get out there and we want to win it...but we never really get the orientation of the process; so we talked to the girls more about doing it, and doing it to the best of their ability, through the training process, through the final preparation, through the races and then let the result take care of itself. It is really hard to stop someone thinking when they take the first stroke at the World Championships final and to focus on the fact that the next thing I care about is the 2nd stroke. It is not always that easy to make that change from sitting in a boat and thinking how is it going to be in 5-6 minutes to what is happening in the 5-6 seconds. How am I going to take the next stroke and how am I going to make it perfect? And then they take another one and get it better. That is what we understand by the process of getting up and winning a race, and that process has developed since the first part of the first camp together where we try to explain to the athletes that in the day to day operation, that within the training session, as part of a training session its not what comes out at the end that you want to concentrate on but its how we get there. It's about the process, as the result will happen anyway. The result will only look better if we keep thinking about the process about how we achieve that final solution. This took a while to get through but it did get through in the end.



5. Technical preparation with 3 areas because only win races in your department if you understand the game e.g. the BLR W8+ always go fast in the first 500m (1:29) but slower each 500m (2:07 in last 500m) and therefore do not understand the sport of rowing; do not win races like this! Do not win races by getting slower and slower down the course – we are in an aerobic sport where the aerobic energy system has the highest % of your energy requirements so you actually race like you are in an aerobic sport; so you try to teach our crews to have even splits as they can to make the pace in the beginning of the race that you are able to maintain; The W8+, and all the winning crews, have managed that reasonably well with the margins between fastest and slowest times in the W8+ just over 1 second. The one thing that is still missing in our W8+ is that we go home is that we go home really strong. (These changes will come in the next 2 preparation areas). Remember in the M8+ that didn't look all that good at the 1999 WC and were okay for 1700m but lacked the finish in the last 300m but in the end they were able to build home very well and look at the result in 2000.

Remember what you are trying to achieve then set steps to achieve goals.

Physical Development

Cannot change the genetic makeup and the physical size of someone especially in a country like ours where the elite female rowing group is small (only 30-35 rowers are available for the Olympic Team) so are focusing on

- General fitness
- Endurance
- Strength
- Power

The message to the girls has been that we do not train enough! Our overall training volume is not enough to be successful in women's rowing in the world. It may be enough to beat each other in the country but more low intensity aerobic training (U2-U1) must be done for longer times than previously where women have been trained the same as men. But women are not like men because they are better endurance athletes whereas men are better at faster, stronger more dynamic exercise. So if we coach our women like our men then we can cause a problem in itself.

On the other hand, women are not very strong naturally. So we needed to develop strength training programs that cater for them. We basically moved away from pure strength endurance training development into strength, dynamic strength and dynamic power, we introduce more strength work on the water with regular power strokes to get general power development adaptation into specific power development. This has happened quite well over the nine months before the World Championships but this can still improve greatly and will probably take until 2003 to get to the ideal level.

Technical Development

Technique is always something that is hard to talk about here in Australia because we have an idea that technique is something that looks good. As an outsider coming into the system who doesn't speak the English language very well I have relied on very simple basic messages to the rowers without the waffle. We said right from the start at the beginning of the year that we wanted to go right back to the basics and stop making the catch something that takes 55 seconds to explain. Try to all start from the same basic level with the same terminology; same simple message and therefore understanding or what is required. The athletes really appreciated this approach from the coaches.

So what is the best practice technique – what is that people around the world do to make them successful? So looking at what makes crews fast is not necessarily what you see from the outside but what is happening in the water. How we actually move the boat with every stroke that we take.

Our crews do have some shortfalls in this regard...

1. Applied Power: the power that we develop we need to apply. There is no point in having people very strong and can throw weights around in the gym and then get into the boat and cannot apply it – applied power makes the boat move.
2. Stroke length is a clear deficiency – our rowers generally row too short with little forward reach; need to get length off of the back with the hands moving away, the body rocks over establishing good forward length; then the blade can be put in the water and the power applied under the water in a long powerful accelerated stroke; also there has been a developing culture of Scullers not finishing off the stroke – we emphasized the Scullers finish with their hands apart not just after the cross over so that they use the last 5-10 degrees of the stroke to get a lot more run on the boat; especially with the W4x which won the Gold at U23 and came 4th at the World Championships;
3. Efficiency, Boat Run and Distance Per Stroke: the whole stroke length idea means we have a more efficient stroke, more time for each stroke, we can actually drop the stroke rate because we move the boat longer per stroke; so this creates boat run with good control on the recovery and one thing that we have always pointed out to the girls is that we wanted to get more distance per stroke – more cms per stroke will be a lot at the end of the race; All of our crews (Senior A, U23 and Junior) have rated comparably lower than the rest of the crews; so we achieved the same boat speed as the rest of the world but with lower rating.

These technical goals with looking at the stroke and trying to make more dynamic and longer have been achieved in quite a short time period.

Selection Process

We developed a procedure that was transparent and accountable. The new National Ranking system ranks athletes as they progress through the season so that

athletes are eliminated based on their ranking without any subjectivity. There were no appeals from the selection process this year.

Everyone in the national scene has the right to know what the priorities are so everyone in the Women's Department knew that the W8+ was priority which would double up with the W4-, W2x, and W2-; the LW4x was agreed as the boat for 2001 but will be the basis for a future LW2x.

Each boat class knew exactly what was required and when: Final speed order trial at the end of the selection week enabled crews to basically select themselves.

Training Process

After selection the crews go into a very structured training process in their final preparation for racing at World Championships, World U23 Regatta and Junior World Championships.

Sports specific – as much as we can from swimming,



cycling, running programs in the end we are still a rowing sport and we still require a certain individuality as how rowers train; the best practice is established by looking around the world and see what programs are successful and try to put into our program; Gender specific is also necessary.

What we didn't allow this year was to allow the crews to go off and do their own thing. This has been one of our major problems to let crews do whatever they want – we are in the same sport and before we start individualizing we must standardize. So this year we standardized. We tried to go back to clear periodisation in the planning of our training and put the activities within our country to fit in with this periodisation.

Microcycles of 2.5 days were followed for each of the women's crews i.e. 2 ½ days of work followed by ½ day rest – Day 1 with emphasis on loading + general strength, Day 2 specific power, Day 3 transformation of aerobic strength and specific power, overall strategy the same but with different volume and intensity for different age categories.

Goals were set for athletes, crews and program with short, medium and long term strategies. Then the daily training programs were devised around the basis of 3 weeks of hard, increasing work then 1 week of super compensation/recovery.

We are now in a very good position because the season is finished and we can sit back with all the coaches and can analyze what worked and did not. This is the way to work out best practice.

Coaching – Art or Science

I believe that we can talk about the development of both parts in coaching skill with knowing how to work with scientists to get the knowledge out and being the artist.

We need to know:

1. Training and Teaching Methodologies – basic principles, how they work and how to teach them
2. Biomechanics – explains what's under the water and what makes the boat move
3. Physiology – to understand how the athletes improve the performance
4. Psychology – individuals react differently to all that is going on around them in training/performing
5. Medicine – need to know if, but, when even though we need to rely on the specialists.
6. Feel, touch, intuition for the sport also necessary as need to see how all the above is working with your athlete. E.g. Vicky Roberts at altitude camp said "could not do it anymore" and had to be taken out of the boat for a few days.

Need a balance between the science and the art! Need to keep up to date with the sports around the world, need to analyze and know the best practice in the sport, we go across the board and look at all aspects which keeps confidence in working our artistic feeling, good judgment to make it really successful combination. I don't think we are going to be successful coaches if we rely on one or the other.



ASSOCIATION OF ROWING COACHES, SOUTH AFRICA

PHYSIOLOGY

LACTATE & THRESHOLDS FOR TRAINING

What is the "anaerobic threshold"?

Before we define the "anaerobic threshold" (AT) it should be pointed out that there is no clear consensus on what this term means. This was and still is a controversial area. So when we define it, the reader should know that others may use a different definition. Many sports scientists would prefer to eliminate the term altogether. However, it is still commonly used by coaches, training books, the popular press and many sports scientists.

Originally some sports scientists thought that there was a point of exertion where the body started to use anaerobic energy heavily. This point corresponded to a sudden change in the patterns of oxygen consumption compared to carbon dioxide output as well as a rapid accumulation of lactate in the blood. Because it was a sudden change, like the passing from one physiological state to another, it was called a threshold. Because it was thought that the changes in metabolism at this point were 1) due to limited oxygen and 2) the start of using anaerobic energy, it was called anaerobic. Hence the term "anaerobic threshold" was used. It was an unfortunate choice of terms since it probably has led a lot of sports scientists, researchers and coaches down the wrong path.

"Anaerobic" is not appropriate since anaerobic energy is produced even at resting levels. As exercise gets more intense but still very much below the point that is designated as the "anaerobic threshold" anaerobic energy increases even though very little additional lactate may show up in the blood. If the athlete is well conditioned, most of the pyruvate* produced by the anaerobic system is utilized immediately for aerobic energy. In these athletes there will be little indication of increased lactate production even though the anaerobic system is being actively utilized. Also above the point that is designated as the "anaerobic threshold" there is still a steady increase in the use of aerobic energy till VO₂ max. Thus, the use of the term "anaerobic threshold" is a misnomer because there is no sudden switch to anaerobic metabolism and there is a continued increase in the use of aerobic energy. Something completely different is happening at this point.

**Pyruvate is the end product of the anaerobic system called glycolysis. Glycolysis is what one is referring to nearly all the time they use the term anaerobic. Pyruvate is either immediately used for aerobic energy in the cell or converted into lactate. Very little pyruvate remains as itself which is why lactate is always the term used.*

A quick history of thresholds.

In 1959 Wildor Hollman of the German Sports University in Cologne presented a paper on what he called "point of optimal ventilatory efficiency" at the Third Pan American Congress of Sports Medicine. The presentation was based on the author's hypothesis that the ventilatory and lactic acid threshold exists and how to determine each. In 1964 Wasserman and McIlroy used the term "anaerobic threshold" to describe similar phenomena and the term "threshold" became popular internationally. In the early 1970's, Alois Mader, was working with runners in East Germany and discovered that when these runners used a pace faster than the one that generated 4 mmol/l in a progressive exercise test that they quickly became exhausted. When the runners ran at a slightly slower pace they were able to continue running for an extended period of time. Mader escaped from East Germany and went to work with Hollman at the German Sports University in Cologne and popularized the 4 mmol/l lactate measurement. At the same time some researchers were using the term "maximum steady state" but had not yet connected it with lactate levels. In the late 1970 two German researchers, Kinderman and Keul started using the term maximal lactate steady state to describe the point where an athlete could not go any faster or harder without proceeding to exhaustion. Since that time the term "threshold" and "maximal lactate steady state" have become part of the training and testing lexicon. In 1981, Bertil Slodin, a researcher at the Karolinska Institute in Stockholm and a Canadian Ph.D. student there named Ira Jacobs, used the term "onset of blood lactate accumulation" or "OBLA" to refer to effort level in runners that corresponded to the point at which blood lactate begins to increase exponentially. A blood lactate level of 4 mmol/l was associated with this point and in most instances today "OBLA" means a 4 mmol/l blood lactate concentration. All these researchers quickly realized that the lactate level at which this threshold took place varied substantially between athletes while the myth has persisted that they said the 4 mmol/l level was the actual threshold level.

What is the currently accepted use of the term "anaerobic threshold"?

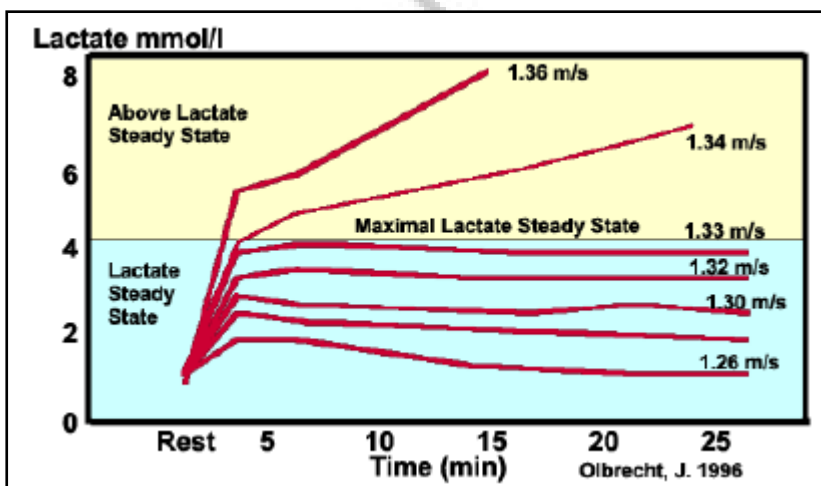
The most common use of the term "anaerobic threshold" is to describe a phenomenon that takes place in all athletes - namely the maximal speed or effort that an athlete can maintain and still have no increase in lactate. At this speed or effort, lactate levels in the blood remain constant. Any increase in effort or speed above this level will cause lactate and its associated high acid levels to increase steadily. This will eventually force the athlete to slow down or stop. The time to cessation or slowing down will depend upon how far the athlete is above the maximum steady state effort, the event the athlete is competing in, the type of athlete (strength or endurance) and conditioning.

It is possible for the athlete to exceed the anaerobic threshold level by small amounts and still exercise or compete for a substantial period of time, sometimes up to 25-30 minutes. The lactate levels will gradually increase in the blood but will not stop exercise for this time. However, substantial increases above the anaerobic threshold will

usually shut down the athlete very quickly, often in as little as 20-40 seconds.

Because the anaerobic threshold represents a point where the lactate in the blood reaches a maximum steady state and is an equilibrium between lactate production and lactate clearance, we like two other terms better. The first is maximum lactate steady state (MLSS or MaxLass). This emphasizes the steady state and equilibrium concepts. The second is "lactate threshold" (LT). This retains the threshold concept but puts the emphasis on "lactate" and not "anaerobic". Both of these terms describe the same point of exertion.

The following chart illustrates the concept of a maximum lactate steady state. The swimmer below is able to maintain 1.33 m/s with a constant lactate level of about 3.8 mmol/l. At 1.34 m/s the swimmer is able to continue for an extended time as lactate slowly builds up and finally stops between 20 and 25 minutes. At 1.36 m/s the swimmer stops after 15 minutes. The maximum lactate steady state lies somewhere between 1.33 m/s and 1.34



m/s. For practical purposes it is assumed that the lactate threshold or maximum lactate steady state is 1.33 m/s.

What other terms are used to express this concept?

Many have used other terms such as the individual anaerobic threshold (IAT) and the "onset of blood lactate accumulation" (OBLA). The term IAT (Individual Anaerobic Threshold) has become popular in contrast to the original assumption of many that the anaerobic threshold nearly always took place at blood lactate levels of 4 mmol/l. Several sports scientists wanted to emphasize that the anaerobic threshold or MLSS takes place at different lactate levels for different athletes and that using a fixed level of 4 mmol/l for everyone was very misleading. In fact IAT's or MLSS's range normally from 2 mmol/l to 6 mmol/ with some people outside this range. Also MLSS's vary between sports for the same individual. So triathletes cannot use a fixed lactate level to determine their MLSS for each of the sports in which they compete.

Despite all the problems with the term "anaerobic threshold" the abbreviation AT has become an accepted part of training terminology. It will probably not go away for a long while because it remains a favourite with coaches, athletes, the press and even a lot of sports

scientists. However, the term "lactate threshold" or LT is now becoming more popular. This has happened in the last 5 years.

What is the mechanism behind the lactate threshold?

Below the lactate threshold most of the lactate produced is being used as fuel for aerobic energy some place in the body. It could be used very close to the muscle generating the lactate or carried by the blood stream to other muscles and be used for aerobic energy. It is also used by the heart and some is converted back to glycogen. Physiologically the body as a whole is in equilibrium between lactate production and lactate elimination. The rise in blood lactate levels above resting levels as exercise intensity increases is an indication that some muscle fibers are not able to handle all the exercise load aerobically. The excess lactate produced from these muscle fibers moves to areas of lower concentration such as the blood stream, neighboring muscle fibers and the space between the muscles. Other muscle fibers have plenty of excess capacity for aerobic energy and these fibers can use the lactate produced by the fibers with limited aerobic capacity.

When we measure the lactate in the blood stream we are observing the movement of the lactate from muscle fibers that produce the lactate to those parts of the body that can utilize it. As exercise intensity increases the body reaches a point where it cannot utilize all the lactate produced. Above this point, which we call the maximum lactate steady state (MLSS), anaerobic threshold (AT) or lactate threshold (LT), the athlete is not able to eliminate lactate at the same rate as it is produced. As a result lactate starts to accumulate rapidly. It should be noted that the rate at which lactate accumulates above the threshold varies. Generally, the slower the rate

of lactate accumulation above the threshold the better the performance in long distance events. For shorter competitions such as those found in swimming, rowing, track cycling and running (events 5000 meters or under), the ability to utilize the anaerobic energy system to a high level (produce lactate quickly) is important.

How can one change the lactate threshold?

With training the lactate threshold will change primarily for three reasons; lactate utilization increases, lactate production declines or lactate clearance increases. Here's how it works:

1. **Lactate Utilization Increases** - Training can affect the utilization of lactate primarily in two different ways. However, to better understand the following discussion you should remember that lactate is produced from pyruvate and pyruvate is the end product of the anaerobic process. See the diagram below.

First, better oxygen utilization. With certain types of training there are adaptations within the muscle fiber that let it utilize more of the available oxygen. These

changes within the muscle are physical as well as chemical. This higher utilization of oxygen means more of the pyruvate will be used for aerobic energy. When this happens less of the pyruvate will be converted to lactate. Often there is plenty of oxygen available in the muscle fiber but the fiber does not have the capacity to process the pyruvate aerobically. Changing this condition is one of the fundamental objectives of training. (#1 on Chart below)

Better oxygen delivery - Other types of training can bring about adaptations in the cardiovascular system, making it stronger and more efficient. This enables delivery of more oxygen to the muscles and at a faster rate. There is considerable evidence that as more oxygen is delivered to the muscles, less lactate is produced. This doesn't mean the anaerobically supplied energy decreases with improved oxygen uptake (the same amount of pyruvate is produced). It means more of the pyruvate will be used in the aerobic process and thus less will be converted to lactate. So for the same amount of anaerobically delivered energy less lactate will be found in the blood stream if the oxygen to the muscle increases. (#2 on Chart below)

One of the main adaptations that facilitates oxygen delivery is more capillaries. Another change that increases oxygen delivery is an increase in the proportion of red blood cells to plasma in the blood. The higher the percentage of red blood cells the more oxygen that can be delivered to the muscles. Some types of altitude training have an effect on the oxygen carrying ability of the blood.

Despite the better oxygen delivery, some lactate will be produced in muscles that receive plenty of oxygen because of other reasons.

2. **Second - Pyruvate Production decreases.** This happens either because adaptations cause more fat to be used or because anaerobic capacity decreases.

More use of fats, less production of pyruvate.

There will be less production of pyruvate as the muscles adapt to use more fats as fuel for aerobic energy. The higher utilization of fat means there is less need for glycolysis and consequently less pyruvate is produced. Certain types of endurance training enable the body to process fats easier. (#3 on Chart below) It should be noted that this adaptation does not imply that the anaerobic process is not as strong, just that the signals that activate it are not as frequent. This is in contrast to the next situation where anaerobic capacity is actually lower.

Lower anaerobic capacity, less production of pyruvate, Some types of training actually change the anaerobic capacity. In fact some coaches and sports scientists believe this is the main reason for short term changes in the lactate threshold. When this happens the lactate threshold will automatically change because pyruvate production is changed.

When the anaerobic capacity is lowered less pyruvate is produced for a given effort level. Thus, the lactate threshold will increase without any change in the ability of the body to process aerobic energy or to shuttle lactate. When the body is faced with less pyruvate being produced, less will be converted to lactate at any given effort level. Similarly, an increase in the anaerobic capacity will lower the lactate threshold without any change in the ability of the body to process aerobic energy or to shuttle lactate. In this case the body has to deal with more lactate. The lactate threshold is always an equilibrium between lactate production and lactate elimination. (#4 on Chart below)

It is thought that the anaerobic capacity of an athlete is innately capped. There is a maximum rate of anaerobic energy production which the athlete seems unable to exceed. However, certain types of training affect the rate at which the anaerobic system can produce energy. Are these contradictory statements? No. It seems that the anaerobic capacity can be lowered from its innate maximum by specific types of training, usually associated with endurance training. High volume low level workouts will suppress the anaerobic capacity as well as long hard workouts near the lactate threshold.

The anaerobic capacity can be brought back to its innate levels by high intensity training well above VO_{2max} . This will cause the lactate threshold to be lowered. This is not something an endurance athlete would want to do before an important race but swimmers, rowers, runners, speed skaters, track cyclists etc are very interested in having a high anaerobic capacity for important competitions. There have been studies of swimmers which have shown that there is no improvement in the lactate threshold late in the season as important competitions get near. Several prominent sports physiologists have then said that this shows that the lactate testing has little relevance for swimming. Nothing could be further from the truth. What is happening to swimmers is that late in the season training intensity increases substantially and this raises anaerobic capacity back to innate levels. This has the effect of lowering the lactate threshold or keeping it at about the same level. If coaches are not aware what is happening to the anaerobic system then they could prescribe the wrong training for the athletes. By the way this may be a controversial area. I say "may be" because there is not much written on it and so it hasn't been discussed much. It is definitely not considered a factor in why the lactate threshold changes by many sports scientists. However, it is consistent with what a lot of coaches observe in their training programs. Some sports scientists are starting to write more about it.

3. **Lactate Clearance** - Training helps the body becomes more efficient at removing lactate from the producing muscles and shuttling it to other parts of the body where it can be used. This eases the acid levels in the producing muscles and thus lets them operate at a higher energy

level before producing the acidosis levels that slow down energy production. (#5 on Chart below)

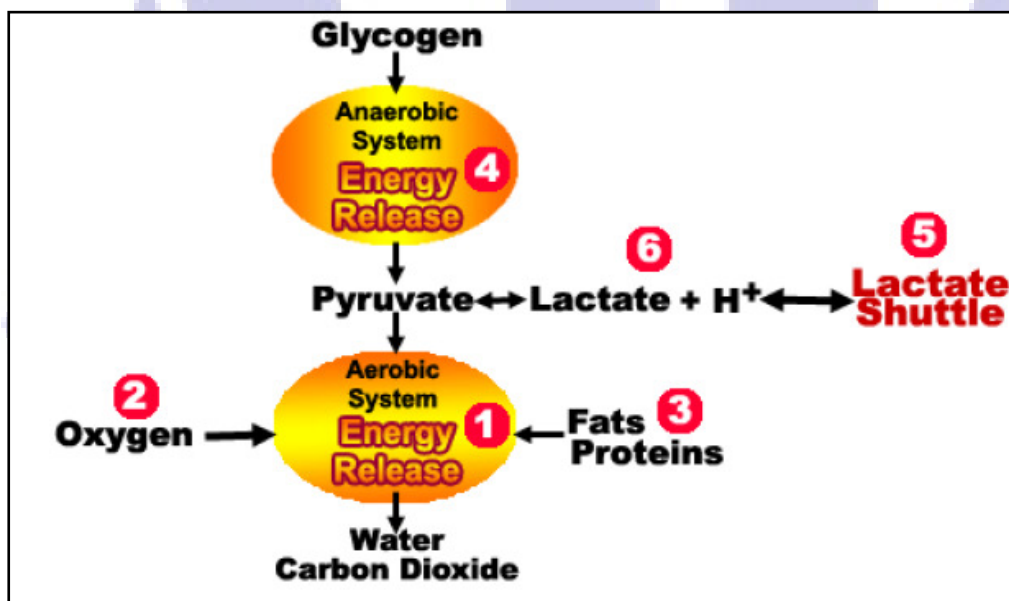
Also training for better oxygen delivery can help the lactate shuttle as the increased capillary system will help clear the lactate out of producing muscles and into the blood stream. The same adaptation facilitates the transfer of lactate from the blood to other muscles for elimination.

Buffering - The muscles can be trained to buffer some of the acid accumulating in the producing muscles. The hydrogen ions causing the problems with contraction are neutralized and this allows even more lactate to be produced before there are problems with contraction. However, it probably does not affect the threshold since it does not slow down lactate production. Buffering enables the athlete to compete for a longer time at effort levels above the threshold. Little is written about how to train this buffering capacity though it is thought to take intense workouts to increase the buffering capacity of the muscles. Coaches often prescribe intense workouts called "lactate tolerance" sets to do two things; 1) get the athletes accustomed to the pain that accompanies high acidosis and 2) increase the buffering ability of the producing muscles. (#6 on Chart below)

increase will reduce the production of lactate but will also help the lactate shuttle. Also different types of training may be necessary to effectively change a process. To lower the anaerobic capacity may require a combination of intense workouts near the lactate threshold plus long slow training. Obviously what will work for the regional level athlete may not work for the athlete preparing for Olympic trials since highly trained athletes may have maxed out on several different adaptations. Also what may work for enhancing one of these factors may hinder another since often training exercises are not surgically precise.

The closest we have seen anyone answer this question is the book by Jan Olbrecht which looks at training exercises based on how they will change specific aspects of conditioning. It is a book on swimming but provides a template or schema for developing training exercises that are appropriate for any endurance sport. Also Olbrecht's book emphasizes that these adaptations have to be timed in a precise sequence. Some take several months and even years while others can be done in a few weeks once some of the other adaptations have taken place. Olbrecht works with swimmers, triathletes, runners, rowers and soccer teams. His athletes won 28 medals at the Athen's Olympics.

Are there other thresholds?



There is the point at which the baseline lactate rate starts to rise. (A baseline level is the amount of lactate generated at a slow pace used for recovery or warm-up. See the chart below.) Some have called this the "aerobic threshold." This particular point has some meaning because it represents an effort level at which the lactate in the blood starts to rise. Some have suggested that this point is the effort level at which the body starts to recruit fast twitch fibers. Fast twitch fibers generally produce more lactate than slow twitch fibers. However, this point responds to training

Detraining - Lower training levels or stopping training altogether can reverse a lot of these processes and this will also affect the lactate threshold.

just as the lactate threshold does so what is going on in the body at this point is probably a combination of things, one of which may be a recruitment of new fiber types. But it is too simplistic to describe this point as the point where fast twitch fibers are first recruited.

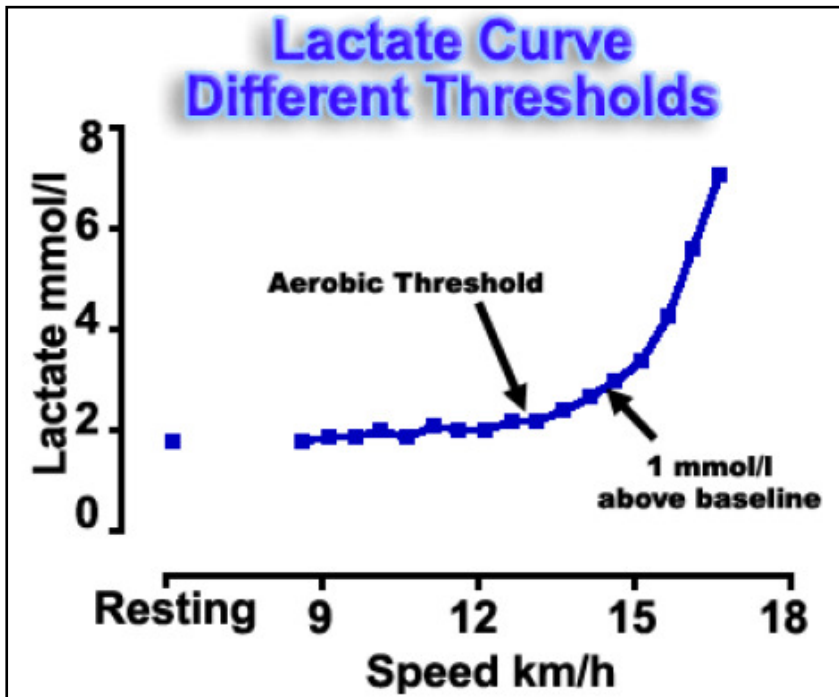
How does one train to change the threshold in all these different ways?

This is an interesting question since we haven't seen anyone address it completely. There is a lot of advice on how to change the threshold but none approaches it on the basis of changing six different processes. Also one type of exercise may work on more than one of the six processes. For example, whatever causes capillaries to

If you want to get really confused, some sports scientists have identified a third threshold which they identify as the effort level that generates 1.0 mmol/l of lactate above the baseline. Some have called this pace or effort the "lactate threshold". However, we use "lactate threshold" to mean the maximum lactate steady state and we will just refer to this third threshold as 1.0 mmol/l above baseline. This lactate level is approximately the lactate level that a

marathoner maintains during a race and is definitely below the MLSS for most athletes.

This is an interesting question. Since there is a lot written about them it must be for a reason. Also we spent a lot of time above discussing how to train to change the lactate threshold. We have just mentioned that the pace that is 1.0 mmol above the baseline lactate readings corresponds roughly to the pace that a marathon is run at. Hence it is very useful for distance runners to know this point and judge their progress by how much this point is changing with training. A well trained athlete can run, bike, swim or row for several hours at this pace and not slow down. Ironman triathletes and road cyclists also compete at a pace close to this level or just below it.



You will notice on the chart above that we did not indicate the lactate threshold. That is because there is no clear point on the curve that can be identified with this effort level. The other two effort levels are more easily identified which is one of the reasons they are popular. However, they require that several lactate readings be taken in order to clearly identify the baseline and where it starts to rise.

Different training programs use these different levels. Coaches and athletes should know what each means in case they hear them used. However, the biological processes at the lactate threshold, the point 1.0 mmol/l above baseline and the point at which lactate starts to rise may be quite different metabolically from athlete to athlete. We identified 6 processes that affect the lactate threshold. It is unlikely that two athletes with the same lactate threshold have identical physiological profiles. In other words if you compared two athletes at each of these thresholds you may find very different processes going on within the athletes even if the effort levels at the threshold are similar. For example, two athletes at the lactate threshold may be using the aerobic and anaerobic systems quite differently.

The coach is trying to maximize the energy produced for these two athletes during a competition and not necessarily manipulate a particular threshold. Thus, the coach tries to find the optimal balance between aerobic capacity and anaerobic capacity depending upon how the competition will unfold and the current conditioning level of the athletes.

Are these thresholds important?

While knowing the lactate threshold is important for competition, knowing the threshold exactly may have less relevance for training despite our long discussion above. Above the lactate threshold there will be an accumulation of acid in many of the working muscles because production is outstripping clearance and this is extremely relevant during many types of competition. However, during training it is not as important to know

or act on the lactate threshold pace or effort even though much of training has the objective to change it. First, there is nothing special, biological or metabolic, happening at the lactate threshold or at any other threshold. There is no new fiber group being recruited or transition to something different (even though the term "threshold" is used the processes are all continuous). The important thing that happens above the threshold is that the increasing acidosis will shut down the muscles in a short time. Thus the total volume of possible exercise will be less. Also, frequent efforts at levels above threshold may damage the muscle cell structure and end up lowering aerobic capacity instead of increasing it.

For the "more is better" school the lactate threshold represents the highest effort level that the athlete can maintain for a long time. Thus, prescribing workouts at this level will provide the most difficult stimulus the body can handle for an extended period of time. This approach has some problems. Namely,

- working out at the lactate threshold will not recruit all the fibers in the muscles used for a sport and thus not train every muscle that will be needed in competition. The percentage of fibers recruited at the lactate threshold will vary a lot between athletes. One athlete who has a LT at 70% of VO₂ max will not use as many fibers at LT as the athlete who has an LT at 93% of VO₂ max. As we mentioned above what happens at LT may not be the same for each athlete. Thus, coaches have to design workouts for each athlete based on each conditioning profile. Even two marathoners who have the same LT pace may have very different conditioning profiles. The two may have very different anaerobic capacities and should train differently because of this.

One way to train all the fibers is to do interval training at high intensities near VO₂ max. This way the athlete whose LT is 70% of VO₂ max can train all the fibers.

- Too frequent extended workouts at the LT is a formula for over-training if used too frequently. What is too frequently? This is a murky area. But a runner who completes a marathon will usually do so at a pace that is lower than the lactate threshold. This runner often needs several weeks to recover fully because of muscle damage. Very few would prescribe a marathon as a workout. However, some coaches/training advisers recommend frequent LT workouts and intervals above threshold. These workouts accumulate substantial mileage during a week and often come close to subjecting the body to the same volume and intensity as a marathon. Even if spaced out every 2-3 days such workouts and competitions done too frequently will break down rather than build up aerobic endurance. If the purpose or training is to break down cellular processes and then give them time to rebuild to a higher level, it is hard to see how continual high intensity workouts will allow the rebuilding process.

Is measuring these thresholds necessary?

The answer is NO! Some very successful coaches have questioned the value of finding the lactate threshold. They don't claim it doesn't exist or that it isn't a good predictor of endurance. They say it is not necessary to measure it to prescribe good training. Their positions have been stated above but to summarize them:

The lactate threshold is difficult to measure and takes too much training time to find it. There is a much simpler approach, also using lactate testing, that works just as well.

There is no proven benefit to train at the threshold versus training at several different levels. In fact given that there are a multitude of adaptations an athlete desires it is important not to be pre-occupied with training at the threshold.

The threshold will mean different things to different athletes and they are not always obvious. For example, a well conditioned top endurance athlete will have a lactate threshold at an extremely high effort level. This effort at threshold will be very stressful on the aerobic system since the athlete may be close to VO₂ max at this point. Because the aerobic system is highly developed for this athlete, it will be using most of the pyruvate produced by the anaerobic system. There will be little lactate in the blood till the anaerobic system is highly engaged. Thus, at threshold the elite athlete is utilizing not only the aerobic system at a high percentage of max but also the anaerobic system at very high levels. Both systems are under high stress.

For regional athletes who compete in local endurance events and have a much lower aerobic capacity there may not be too much demand on their aerobic system at the lactate threshold. They will not be very close to VO₂ max at LT and it is highly unlikely that they will stress their aerobic system at threshold as much as the elite athlete will. Also it doesn't take much activation of the anaerobic system to produce the lactate that will be in the blood at threshold. Hence the regional level athlete is not nearly under the same stress as the elite level athlete at threshold. This sounds counterintuitive to most people but is easily understood once you realize what causes the threshold.

This point of view has evolved from the experiences of many sports scientists from the University of Cologne.

How long can an athlete exercise at these thresholds?

This will obviously vary by athlete depending on training level, types of recent workouts, muscle composition, diets, tolerance for discomfort, the environment and other factors. The pace just below 1.0 mmol above baseline can be sustained for hours. The athlete is burning a high percentage of fat at this pace and there is enough fat in us for hours of exercise (even those athletes with low body fat). A lot of training for long distance endurance athletes is aimed at training the muscles to burn more fat.

Most athletes can usually train at the lactate threshold (LT or MLSS) for about 60 minutes continuously. Some can train up to 90 minutes. The limiting factor is fuel for energy (glycogen) and this will depend mainly on recent workouts and diet. When the athlete runs very low on glycogen the muscles cannot sustain the LT pace or effort and will slow down. It will be 36-72 hours before glycogen stores are fully replenished. Let us illustrate the importance of glycogen with two ice hockey games. A couple of years ago, four teams were competing for the NCAA hockey Championship. The semifinals were on Friday and the finals were just a day later on Saturday for financial reasons. Hockey doesn't attract much of a television audience so most money generated by a championship is through attendance. People will not wait around a few extra days for a championship game. Well, one of the semi-final games finished in regulation with a winner while the other went to three sudden death overtimes of 20 minutes each. If you've ever watched a good hockey game you know it is the most intense sport on the planet. During a sudden death playoff game there is only one gear and it is all out. The teams that played the three overtime game were using as much anaerobic energy and glycogen as possible. During the finals, one day later, the team that won in regulation walked over the team that played three overtimes. One commentator said they must have had a let down psychologically after the dramatic overtime win. Nonsense! They didn't have any glycogen to fuel the high intensity efforts needed for hockey.

Similarly, an athlete that does an extended workout at LT or higher will be unable to complete a similar workout until the body's glycogen is replaced, often several days. Not every athlete is the same on this. But just because an athlete can do a long LT workout it may not necessarily be

a good thing to do. Some coaches caution that training sessions at the lactate threshold for a prolonged time can be very counter productive.

Should an athlete train at levels higher than LT?

Certainly. The real question is how much training above the LT should an athlete do and at what level. This is a very controversial area. There are studies that show high intensity training provides excellent results and there are studies that show that lower levels produce the best results. There is research that shows that the best aerobic training is workouts near VO₂ max but that you can not do too many of them. A lot of what gets published is based on research studies done by academics and is based on 8-12 weeks of training because that is when academics have students to use as subjects. Basing long term training objectives on this type of information is risky.

One coach said that if you are in a hurry, then you will have to include a lot of high intensity workouts. There is no other way to train muscle fibers that don't get recruited till high intensity efforts.

Another coach who took a different tack said that you are "training to train". Early season workouts are mostly below threshold so that the athlete will develop the base to do more intense workouts later in the season or in later



years. He described training like a ladder. You have to train at the first rung before you can attempt the second step. As you move up the ladder your body is better able to handle the highly intense training that will eventually come. This obviously will depend on the sport, the amount of time available for training and the timing of important competitions.

Before leaving this question we refer the reader back to the diagram above which illustrates the various factors affecting the anaerobic threshold. There are so many different factors which affect performance (and the diagram doesn't cover them all) it is irresponsible for someone to say this is his or her "favorite workout" in the sense that this is what will condition the athlete better. These may make good magazine articles but they don't make good sense in training.

No workout, no matter what the intensity or the distance, can hope to train more than one or two of the factors affecting performance. Successful training is the culmination of a variety of different types of training. There are so many adaptations that training must provoke and each of these adaptations needs a different intensity and duration. Giving the training a different intensity is like putting an address on a letter. If you only put one or two addresses on the letter it will only go to one or two places. By using only a couple of different intensities in training only a couple of different adaptations will happen.

The purpose of testing and other assessment procedures (competition results and success in training) is to tell the coach and athlete what adaptations are necessary for further improvement. Then the athlete's "favorite workout" will be the one that provokes the adaptation to realize this improvement and not what is a popular workout.

What type of tests are done to find the lactate threshold?

There are several types of tests to measure the lactate an athlete produces. These tests are often referred to as protocols. The most common type of test is what is called a graded exercise test. It has several other names such as a step test or a progressive exercise test. An example

of such a test is the chart above of a runner on a treadmill. Essentially this test is a series of exercises at progressively higher intensities.

The athlete will ride a bike on a track or an ergometer, swim several laps in a pool, run on a treadmill or a track, row on an ergometer or complete some other form of steady state exercise. They will start at a low level of effort. After completing the first stage, the coach or sports scientist will take a blood lactate reading as well as

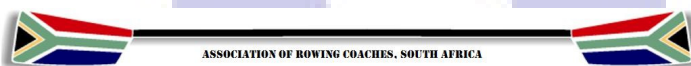
other measures such as heart rate, perceived effort, or measures of oxygen consumption if they have the specialized equipment. (These tests are best done in the field because transferring results from a laboratory setting to the practice environment sometimes introduces unpredictable differences.)

After the first step or stage is completed, the athlete completes a second step at a higher effort level. The athlete then completes additional steps as determined by the coach or person supervising the tests. This procedure is described in more detail in the Lactate Tutorial. The athletes usually complete the test by attempting a level of exercise that will cause them to reach exhaustion but this is not necessary and may actually be counter productive.

At every step and at exhaustion, a lactate reading and other measures are taken.

The measurements taken are lactate readings which can be easily done with a portable lactate analyzer; heart rates which many athletes and coaches measure with a heart rate monitor; and perceived exertion which the athlete estimates. Usually, a coach or a trained assistant with a little practice takes the measurements while the athlete is performing the exercise. We know of experienced athletes who have conducted these tests by themselves on a track or an ergometer. However, most athletes have trouble taking their own lactate readings when they are substantially above threshold.

From this testing a coach can estimate the lactate threshold. We emphasize the word "estimate". This type of testing will narrow down the LT range and experienced coaches will be able to come very close to it by knowing the athlete and seeing the shape of the curve. Coaches should do a confirmation test of the LT to be sure. This is just a steady state workout at the estimated LT and is best done in a field setting. The coach will take a couple of lactate readings during the workout to confirm that the athlete is really at threshold.



ASSOCIATION OF ROWING COACHES, SOUTH AFRICA

METHODOLOGY

PRINCIPLES OF TRAINING - REVISITED

I think if you have been in the exercise game for any time at all, you know a lot about the "principles of training". But, I still want to explore this topic a little bit as a prelude to additional training articles that will follow. I will discuss four training principles. Depending on what you read, there are others. This is especially true if you happen to read "Muscle and Fitness". But, I think these main concepts are fundamental to understanding exercise induced adaptation, and encompass most everything else.

1. The Overload Principle

The Cells are Sensitive

We are biological organisms composed of an interdependent assortment of billions of individual cells. It has been said that "every cell in our body is psychological". This may sound crazy, but in a sense it is true. Every cell is in some form or another **sensitive** to certain forms of stress, and capable of initiating a specific **response**.

Training is a cyclical process of tearing down and building up

Part of understanding this overload principle is knowing that the adaptations we are trying to stimulate require synthesis of new biological material. This process takes time! Even as you sit reading, your body is constantly in a state of deterioration and repair. Some cells, like red

blood cells are dying out completely at the rate of 2-3 million every second, and being replaced just as fast! Others, like muscle cells, hang around much longer, but are constantly repairing themselves from within. When we train, we do additional, specific damage to some cells, and use up cellular resources (fuel, water, and salts are 3 examples). When you walk off the track or get out of the pool after a workout, you are **WEAKER**, not stronger. How much weaker depends on the severity of the exercise stress. The cells always seek to maintain *homeostasis*, or the status quo, so the cellular and systemic stress of exercise elicits not just a repair to former levels, but an adjustment, or build-up, of the stressed system that serves to minimize the future impact of the stressor. For example, the depletion of muscle glycogen to low levels by a lengthy exercise session triggers a rebound increase in glycogen storage level. Another example, getting hot and bothered during a run on the first hot Summer day initiates a process of adaptation whereby we, within 10 days or so of repeated heat exposures, turn on sweating faster, more intensely, and over a bigger skin surface area, but lose **less** salt (which means our eyes stop burning when we get that more dilute sweat in them. This **GENERAL ADAPTATION SYNDROME** was described by Hans Selye, and expanded by Yakovlev. If the stress is too small in either intensity or duration, little or no adaptation growth is stimulated. On the other hand, if the stress is too severe, "growth" is delayed or even prevented.

Maintaining homeostasis in the face of chronic stress means increasing the synthesis of specific proteins (mitochondrial enzymes for example) that enable the cell to respond to future demands with less disruption. The optimal training program would be one that maximally stimulated these positive adaptations, while minimizing the cellular and systemic stress thrown at the body in order to trigger the changes. Very hard training does damage and sometimes threatens our health by transiently lowering our resistance to infection. Not to mention the fact that it can stress our time schedules and relationships. Put in real world training terms, the doubled edged sword nature of the body's response to training suggests that we should try to organize training (frequency, intensity and duration) in such a way that we minimize the negative stress effects while still achieving the physiological adaptations desired. This program would then incorporate the appropriate **recovery** time; **1)** long enough to allow the synthetic processes time to occur, while **2)** not so long that reversion back towards the previous cellular state could begin. Finally, our overall training program would have to recognize that some cellular adaptations have a faster response time than others. For example, plasma volume increases dramatically within a week of hard training, while capillary growth occurs slowly years of training. This knowledge will impact the relative amount of training we dedicate to achieving specific adaptations.

Thresholds and Diminishing Returns

If we put this Overload Principle into action, we are talking about regular exercise. When we train, we choose some specific **intensity** and **duration** of effort (or sometimes IT

chooses us!). Then we repeat these efforts with some specific **frequency**. Add in the **mode(s)** of exercise and you have the 4 variables of a training program. Since even the most *untrained* body has a built reserve capacity to handle a substantial degree of stress, there is a minimum threshold for intensity and duration of stress that must be exceeded before additional adaptations are triggered. This is the **minimum training threshold**. For example, in untrained people starting an exercise program, we don't see significant improvements in exercise capacity unless the training intensity exceeds 50% of their maximal oxygen consumption, but this intensity isn't too difficult to achieve. If you have been doing nothing, almost anything helps. However, the threshold level (in terms of the combination of intensity and duration of exercise) for further adaptation *increases* as we become more fit. In elite young and older athletes, the threshold for a **positive training response** may exceed 80% of VO_2 max. So does this mean that every training session should be above this intensity? No, this is an important lesson to learn, usually discovered after repeated injuries, overtraining, and staleness. Exercise at below the higher training threshold can be important for **maintaining** existing adaptations while **allowing recovery processes to occur**. What we are faced with as we continue training is a **diminishing return** on our training investment. The better adapted we are to exercise, the more difficult it is to induce further positive changes. Emerging from this fact is the use of **periodization of training**, a common training term these days. At the elite level the diminishing returns on training investment are clearly evident as athletes train 3-4 hours per day in order to be 1% faster than if they trained 1.5 hours per day. And they gamble this 1% improvement against the greatly increased risk that they will become injured or sick due to the extra training load. So, we each have to decide how important that last 1% is to us.

2. The Principle of Specificity

I think it is safe to say that the media and shoe makers have combined to confuse many young and older athletes about the Principle of Specificity. Nike, and all the folks who sell exercise equipment would like you to believe that "Cross-training" is a key to peak performance. The concept sells more sports shoes and exercise machines, but is it true? Well, no. Any sport you pursue places highly specific demands on your body in at least two major ways. First, the exercise will have a **very specific pattern of joint and muscle coordination**. For a rower, there is absolutely no substitute for rowing. Ditto for swimming. Even when we try to duplicate the basic movement of a sports skill with strength training exercises, the transfer of increased strength to the actual sports movement is often small or absent. In the worst case this type of training can detract from performance of the real skill due to disruption of technique. Second, **the exercise will place high metabolic demands on a very specific group of muscles**. For example, running and cross-country skiing appear to involve many of the same muscles, used in a similar movement pattern. Yet, several research studies have demonstrated that there is NO relationship between VO_2 max measured by treadmill running and VO_2 max measured by cross-country skiing in a group of elite-trained skiers. In contrast, there is a strong relationship

between on-snow skiing and performance on a skiing specific test such as the double poling test.

A high endurance capacity in a specific sport requires both 1) high oxygen delivery (cardiac output) and 2) high local blood flow and mitochondrial density in the precise muscles used. The only way to **optimally** develop the second component of endurance is to train those exact muscles by doing your sport!

Is there ever a place for cross training?

The answer to that question is definitely yes! BUT, we need to understand as athletes what the limited purpose and value of the alternate exercise modes are. For example, I work with some world class speedskaters from Holland on training issues and physiological testing. After a couple of years of observations, it is clear to me that they just cannot skate every day, at least not in a good competitive skating position. The stress on the legs is just too great. So, in order to achieve the training volumes that we think are necessary for success at that level, the skaters also do a lot of cycling, even during times in the year when ice is available. Our choice of cross-training is an effort to combine the needs for highly specific loading with the need of these elite level athletes to train high volumes (20 hours per week or more during the preparation period). Take note though that during the racing season, essentially all hard training is performed on the ice, with low intensity and recovery workouts performed on the bicycle. So even when we use cross-train, we are keep our eyes on the real goal. Or, take me, a 40 year old masters rower for example. During the Spring and Summer back in Austin, Texas, 90% of my endurance training was performed on the water, rowing. However, in the late Fall and Winter (non-competitive period), I rowed less on the water than I could have (No ice in Austin), probably half as much. Why? Mostly because I was mentally tired of rowing, but also because of weather and time constraints. Sometimes I would row on the indoor machine, by no means a perfect substitute for the technique of rowing, but a good simulation for developing basic rowing endurance. But to be honest, on most days, I hate being on that machine for more than about 45 minutes. Embracing the expression "the mind needs rest, but the body needs work", I would often mix in running or cycling on an ergometer with my rowing to increase my total aerobic exercise volume without growing mentally stale. A little bit of cross-training helped maintain my general aerobic base, while allowing me to mentally recharge my batteries in anticipation of another cycle of intense training on the water with my rowing partners.

Another reason to "cross-train" is to avoid injury and maintain muscular balance DURING a period of intense sport specific training. One of the keys to success in sport is staying healthy over the long haul. Weight training by itself will almost certainly do nothing for a runner's 10k time, but if weight training maintains muscular balance in her abdominal wall and low back, preventing injury, then it is contributing to her becoming a faster runner. Why? Because it keeps her running! And, cycling isn't running. But if cycling takes the pressure off tired knees and hips

on a recovery steady-state day, then it will probably make the next running workout better. Cross training should always be limited to those activities that allow us to do our event-specific training workouts with greater enthusiasm and intensity, or less risk of injury. It is a cautiously administered **supplement**, not a **substitute**!

3. The Reversibility Principle

If people were as economical as their bodies, we would not have problems with personal debt and excess world waste production. The human body is nothing if not thrifty!

The iron and protein in those millions of blood cells that die each day is almost completely re-used to build new blood cells! The body does not **build** proteins it doesn't need (except maybe those that make up the Appendix?), and it doesn't **retain**

proteins that are no longer needed! For the athlete, the unfortunate consequence of this thriftiness is the rapid reversibility of training adaptations if training is stopped. In general, I

think it is fair to say that those adaptations that occur fastest when we start training fade away fastest when we stop training. So, a week in bed with the flu will result in a substantial loss in blood plasma volume, but little change in mitochondrial enzyme concentration, and essential no change in capillary density. Once over the virus, a couple of good training bouts will have blood volume back up to normal levels, and cardiac function back to normal as a result. However, take 3 months completely off from your training routine due to a big project at work and you will lose a lot of the adaptive foundation gained over the previous year of regular workouts. If you were highly fit before the break, it may take 6 months to come all the way back. What is clear is that training adaptations are always transient and dependent on chronic stress to the system. However, it does seem that people who have been really fit, and take a break, often seem to be able to return to high fitness levels **FASTER** than those who have not been highly trained before. Whether this is a function of good genetics for training responsiveness, a certain "muscle memory" in the brain or muscle cells of the detrained athlete, or just past knowledge of how to train is unclear, but it does seem to be real.

4. The Principle of Individual Differences

Last but not least on the list of Training Principles is the Principle of Individual Differences.

We All Start Somewhere....different

It is usually practical to describe physical characteristics based on some **AVERAGE**. On average, American men (no offense to my international readers) are currently 5' 9" (1.75 m) tall and about 180 pounds (82kg). But, walk

down a busy street and you will see that there is considerable variability! It shouldn't be too surprising that there is also a lot of variability in our internal characteristics. Heart size, muscle mass, bone diameter, fiber type composition, position of muscle attachments on bone, fat distribution pattern, joint flexibility, etc., all vary from individual to individual. Two examples: **On average**, a 25 year old untrained man will have a maximal oxygen consumption of 45 ml/min/kg. However, there are completely untrained people that have walked into a lab, got on a treadmill and had a VO_2 max of 70 ml/min/kg. I tested a fellow exactly like this myself once. I was



teaching a class and he "volunteered" to perform a cycling max test. I predicted his max for the class based on his exercise history (little if any). Imaging my surprise as he kept cycling and his VO_2 kept climbing and climbing as I progressively increased the workload on the bike! He didn't bother to tell me his sister had rowed in the Olympics until after the test! There are equally

"healthy" untrained young men whose max is only 35 ml/min/kg. That's a 2X difference in aerobic capacity before they do their first workout! This is a physiological gap will not be closed, no matter how hard the "less endowed" fellow trains. If the high VO_2 guy trains very hard, he **might** reach 80 ml/kg/min, a 14% increase. The low VO_2 guy can train equally hard and possibly reach 50 ml/kg/min, a larger 42% increase. The gap can narrow (to 60% here), but it will not go away. Genetics place limitations on our body.

Example number two: **On average**, the fiber type distribution in the thigh muscles of a male (or female) is roughly 50% slow and 50% fast fibers. However, in a study by Simoneau et al, 1989, muscle biopsies from the vastus lateralis (outside thigh) of 418 males and females revealed a range of from 15% slow fibers to 85% slow fibers in different people. Coefficients of variation approached 30%. Again we see that there is considerable genetic variation in a variable that has significant impact on performance. So, we each have to focus on approaching the outer boundaries of OUR OWN physical potential.

Different Strokes for Different Folks

At the Laval University in Canada, the University of Texas at Austin, and three other Universities in the United States, a major collaborative project was undertaken to determine the role of genetic variability associated with individual responses to an identical training program. Fittingly, this project was called the Heritage Study. Millions of dollars were spent to quantify and understand the genetic foundations of a phenomenon that athletes

already know full well. **We all respond differently to a training program.** What this major study clearly demonstrated was that not only is our physiological "starting point" highly individual, but our **training response** is also highly variable. In this study, there were some subjects who essentially did not show ANY adaptation to a very well-controlled training program (measured for example as an increase in VO₂ max), while others increased as much as 40% when doing the exact same training. Some athletes can do next to nothing 3 months then train like a madman, sweat, and spew chunks for three weeks and be in racing shape (ok, maybe too graphic). Others are "hard gainers" that seem to lose everything if they miss 2 weeks of training. Some people tolerate and even thrive on, a high volume of training to reach peak fitness. Others cannot tolerate the same workload, but reach similar performance levels if they intersperse more rest days. We each have a unique psychological makeup. We have different strengths and "weaknesses" within our physiological performance machine that should influence training plan design, and we have different hormonal and immune reactivity that will influence the level of stress we can tolerate and improve under. In the field of exercise physiology, we have learned a great deal about physiological adaptations and the general methods of training that conform to known physiology. This is very valuable information for the athlete to understand whether 24 or 64 (Of course I am biased on that score). But, remember, ANY exact training program that you copy from me or someone else is destined to be, at best an approximation of what will work best for you, and at worst, a total failure.

The Bottom Line

Ok, you love your sport and are motivated to improve, but with so many possible training methods and "experts", What can you do? Well, here is what I think.

First, **understand what training does to your body** Learn the physiology of the sport (hopefully the MAPP will help). Know how your engine works. This will help you critically evaluate the disparate training ideas that are thrown your way.

Next, examine and **learn the biomechanical principles that must be obeyed for performance success.** How do you maximize the efficiency of transfer of your engine power to performance velocity? There is no endurance sport that does not place a premium on good technique.

Finally, **keep a record of what you do!** Use a notebook and pencil, or a fancy computer program, but make yourself accountable to both the training you do in pursuit of your performance goals, and the results. If you do this, eventually you will have arrived at your own personal prescription for success, built from solid general principles, but fine tuned to your personal characteristics. "Success" will vary for each of you in absolute terms; completing a 10k, a new personal best, a city championship, or maybe a world veteran's record! But it all feels the same to the person who establishes the goal, develops a plan, and works diligently to achieve it! **Then you can tell us about it on the MAPP!**



