

STROKEARCS

The Newsletter of the Association of Rowing Coaches, South Africa

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All articles available online at www.arcrsa.blogspot.com



COACH EDUCATION

FINDING OUT WHAT'S KNOWN

Finding Out What's Known

Be skeptical! a skeptic's questions

Sources of Information: religious tracts, anecdotes, popular media, magazines, websites, monographs and books, journals

Journal articles: original-research reports, reviews

How to read reports and reviews

Will G Hopkins
Sport and Recreation
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BE SKEPTICAL!

Ask the following questions about your [source of information](#).

- What is the [evidence](#)?
- [Who](#) says?
- Who stands to [gain](#)?
- Who is trying to [impress](#)?
- Who is pushing their [belief](#)?
- What is the [hidden agenda](#)?
- [Why](#) would it be so?
- [How](#) could it be so?
- Is it reasonable, practical, sensible, [LOGICAL](#)?
- What's a better [alternative](#)?
- Am I keeping an [open mind](#)? [Should](#) I?
- Can I be [skeptical](#) about being [skeptical](#)?

Worst Sources: Religious Texts

- Some regard these documents as the [word of God](#).
 - The assertions therein therefore [cannot be questioned](#).
- Others regard them as an [attempt to explain life](#) in terms of what was known at the time.
- Still others see the darker political side: [fundamentalism](#).
- They contain assertions about the origins of the universe and of life that are [demonstrably false](#) to most educated people.
- Even in the moral realm some tracts [defy common sense](#).
 - Why does a compassionate powerful god permit the [suffering](#) of children and their mothers?
- Best scholarly critique: [The God Delusion](#) by Richard Dawkins.
- [Good novels](#) and short stories are a better source of wisdom about the human condition.

Bad Sources: Anecdotes

- "I tried it and it works!"
- Some great discoveries first develop this way, but be **skeptical**.
 - What works for one person may not work for another.
 - The person may use **hype** to **impress** you with his/her experience/knowledge/insight/helpfulness.
 - Anything new or different sometimes works, either because of the **novelty** (Hawthorne) effect or the **placebo** effect (belief that it works).
 - OK, so it still works, but it usually wears off.
 - For health or performance of individuals, **regression to the mean** can make something work **artificially**.
 - When you feel bad you try something.
 - But statistically you're likely to get better then anyway.
 - So you will think that what you tried made you better.

Bad Sources: Popular Media

- TV, Radio, Newspapers
 - Often a mix of **factoids and fairy tales** deliberately hyped to attract an audience for **advertisers**.
 - The **advertisements** are misleading and exploitative.
 - Articles by **journalists** are often **biased** or oversimplified.
 - **Editorial** policy is **biased** by the media owner or target audience.
 - What they **don't report** is often more important.
 - **Opinion polls** published in these media are particularly bad.
 - A "good" public-relations firm can get whatever opinion its clients want by **skillful wording** and sequencing of questions.
 - The "margin of error" does not refer to a margin for **bias**!
 - Ignore polls not commissioned by a **disinterested institution**.
- Engage with most popular media mainly for **entertainment!**
- Trust only **non-commercial** non-religious public media.

Better Sources: Some Magazines

- Most magazines are vehicles for **unsubstantiated opinion** or **third-hand** information.
 - Their main aim is to **sell advertising** space, not inform readers.
 - Some even specialize in **pseudoscience**, publishing fiction as fact.
- But some are reasonably **trustworthy** and **stimulating**:
 - The information is often **first-hand** (written by a researcher or academic) or second-hand.
 - **New Scientist** is a bit hyped by journalists for a racy image.
 - **Scientific American** is more restrained and usually outstanding.
 - Some magazines specializing originally in radio and TV programs now provide **inspirational** social, cultural and artistic **commentary**.
 - In NZ it's the **Listener**.
 - Find magazines like these to **widen your horizons**.

Better Sources: Some Monographs or Books

- Some are by one author; others have chapters by different authors.
- Often they are **not properly peer reviewed**.
- They usually contain information **already in a journal**.
 - If it's not already in a journal, **why not?**
 - Sometimes they contain an author's **pet theory** that a journal wouldn't accept.
- They are there mostly to **make money** for the publisher, or to get the author **academic recognition** or **promotion**.
 - But some do **inform** and **entertain** superbly.
 - Read those recommended by **trusted** friends or colleagues.
 - Check out reviews on line, but beware of the **reviewer's agenda**.
- **Websites** are replacing them to some extent.

Better Sources: Some Websites

- **Google** and **Google Scholar** are miraculous!
- But recognize and be **skeptical** about the **hype** at sites ending in **.com**, **.co.xx** and even **.gov.xx**.
 - These are no better than any other popular medium.
- Sites ending in **.org**, **.edu(.au)**, and **.ac.xx** are generally non-profit and/or educational and are therefore more **trustworthy**.
- Beware: some **.orgs** are **commercial** sites.
- Very few sites are overtly **peer-reviewed**.
 - **Blogs** aren't. Their content is often inflammatory and false.
 - But their **uncensored comment** can also be valuable.
 - **Wikipedia** is, sort of, but anyone can edit most pages. Trust the information if it looks **researched** and a hidden agenda is unlikely.

Best Sources: Academic Journals

- Journals are where most researchers publish their work.
- Most journals are **peer reviewed** and therefore **trustworthy**.
 - Peer review: the editor sends an article to one or two **experts** for comment, then either accepts the article, rejects it, or invites the author to rewrite and resubmit it.
 - The process should be called **expert review**.
- Some people take notice of a journal's **impact factor**.
 - Impact factor = number of times per year the average recent article in the journal was cited (referred to) in other articles.
 - The range of the impact factor is <0.01 to ~40.
 - The range reflects mainly **research activity** in the field of the journal, rather than quality of its articles.
 - Journals specializing in **reviews** have **higher** impact factors.
 - With **experience** you don't need the impact factor.

More About Journals

- Most articles or **papers** are reports of **original research**.
- Most papers in journals are reports of academic (impractical) **me-too research**: stuff lacking true originality or utility, which researchers have to publish to avoid perishing.
 - It's hard for newbies to distinguish between good and ordinary.
- Some articles are **reviews** of original-research papers.
 - Some journals publish **only reviews** in one form or another.
 - Most reviews are **worthwhile**.
- Find articles by using **Google Scholar**, Pubmed, SportDiscus, PsychLit, and other **searchable bibliographic databases**.
 - Recent issues of most journals are on the **Web** via your library.
 - If a journal isn't on the Web or in the local library, use **Interloan**.
 - Get a **hard copy** of either the abstract or the full paper.

How to Read an Original-Research Article

- Title, Author(s), Institution
 - Get to know the big names and big places.
- Abstract or Summary
 - Skip to the **last sentence or two**, then read the whole abstract.
 - It often omits the most important bit: the **magnitude of the effect**.
 - Be wary of **claims for no effect** based on statistical non-significance ("P>0.05").
 - If the results look interesting, delve into the rest of the paper.
 - **Keywords** at the end of the Abstract may omit words in the title.
- Introduction
 - Usually contains a useful **mini-review** of the field and a statement of why the study was done.
 - Use the Introduction in the most recent paper on a topic to **access earlier papers**.

- Methods
 - **Read bits** of this only for clarification of something in the Abstract, Results, or Discussion.
- Results
 - Should contain only an objective account of findings, without discussion or evaluation. **Skip bits** of it sometimes.
- Discussion
 - The author(s) should explain the magnitude and **clinical or practical significance** of the effect(s), any technical **limitations**, likely **biases**, and the direction of **further research**.
 - **Conclusions** or **practical applications** are sometimes in a separate section.
- References
 - A list of papers cited in the article, in a specific sequence and format. **Find and read** some of them.

How to Read a Review Article

- Title, Authors, Institution, Abstract
 - See if the review is a **meta-analysis**: a quantitative synthesis of studies with an overall magnitude for an effect.
 - The conclusions in a meta-analytic review are likely to be **more trustworthy** than those in a more qualitative review.
- Topic-specific sections
 - See if **your kind of subjects or situation** are covered.
- Conclusions
 - Look for an assessment of **magnitude** of the effect.
- References
 - **Find and read** some of them, especially when you have to write your own review of literature for a thesis or for the Introduction in a paper.

In Conclusion...

- **Be logical!**
- **Be skeptical!**

This presentation is available from:

SPORTSCIENCE sportsci.org

A Peer-Reviewed Site for Sport Research

See Sportscience 7, 2003

TRAINING PRINCIPLES

IS VARIATION OVERRATED?

Much is made of the virtue of variation in endurance sports training. Heck, I've made much of it myself. Some coaches and experts go so far as to say that one should never do the same workout twice in a training cycle. But lately I've come to believe that too much is made of the virtue of variation in endurance sports training, and not enough of the complementary virtue of repetition.

There are a lot of great athletes out there who don't buy into the whole variation thing. Among them is Beijing Olympic Women's Marathon gold medalist Constantina Dita-Tomescu, about whose training the following was written in a *Running Times* article:

Constantina Tomescu-Dita's marathon training is based on a one-week block of workouts that has remained constant for years, with only slight variations for the season and distance from a goal race. Not only are the distances and intensity of each day consistent, but also the location, even the course...

There can be such a thing as too much repetition, of course. But everyone knows this. During my meathead phase, when I lifted weights five or six hours a week with no goal other than getting laid, I did the same workouts over and over with no variation and, predictably enough, after an initial adaptation period my body stopped making any progress. The same thing would happen in an endurance training program with no variation. But I believe that many endurance athletes could benefit from including more repetition in their training.

The benefit of repeating certain key workouts throughout the training process is that it allows for apples-to-apples comparisons of performance and thus encourages the athlete to compete against himself, trying to best his previous benchmark each time he repeats a given session. You don't necessarily have to become fitter and fitter for this process to work. You just have to try harder and harder. Indeed, as some of the recent science on the brain's regulation of exercise performance suggests, one of the most important outcomes of an effective training program is the ability to do more with the same resources. Engaging in a training program in which certain bread-and-butter key workouts are frequently repeated is a great way to enhance this underappreciated outcome of training.

Early in a training cycle, when you perform your first session of your bread-and-butter workouts, you shouldn't kill yourself. Just go hard but controlled to establish a benchmark. The next time you perform the same session, don't try to demolish that standard; just shave it down a tick or two by trying a little harder. Continue in this manner until, in the peak period of your training, you really have to turn yourself inside out to improve your key workout times.

It's not all about trying harder, of course. Training should make you fitter too. But the very process I just described will itself make you fitter and give you the resources to progressively improve your key workout performances. Pushing hard but not too hard in your early key sessions will stimulate physiological adaptations that enable you to reach higher the next time.

You should also manipulate the context in which your go-to workouts occur to stimulate fitness gains that you can then exploit in these workouts. As the training cycle unfolds, there should be an overall gradual increase in your training load that is punctuated by short recovery periods. You will make the biggest improvements in your key workout performances when you perform them within recovery periods.

It is rightly said that you can't improve by doing the same workouts over and over. But when you try progressively harder in each iteration of a key workout and manipulate the context in which these sessions are performed, you're really not doing the same workouts over and over.

ATHLETE DEVELOPMENT

UNDERSTANDING OF, AND EXPERIENCE WITH LONG-TERM BUILD UP PROGRAMS FOR HIGH PERFORMANCE FEMALE AND MALE ROWERS PART 1

Content

1. Competition as the goal of training and long term build up
2. Factors determining performance in competition
3. The choice of training means and methods based on a physiological analysis of rowing races
4. Selection and application of training means and methods
5. Long term build up
6. Training of talented children
7. Training of talented youths
8. Training of talented juniors
9. Training of adults with a long term build up of performance
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1. Competition as the goal of the training and long term build up

The entire training in high performance sports is aimed at competition where athletes can show their best possible performances. The preparation of the athlete determines the outcome of competitions. Winning is the ultimate goal for all athletes, coaches and officials. The rowing events at the 1988 Olympics showed that the level of performance has rise further. Between 1984 and 1988 the achieved times by competitors developed by 0.7% while, at the same time, the density in quality of participating Olympic finalists further increased.

A similar increase in the performance of rowers is expected for the future. The race strategy is still offensive as shown in its structure (behaviour at start, middle part, and finish). Out of the 14 winners of the 1988 Olympics twelve had been placed first or second after 500m and nine out of the 14 winners had a leading position after 1000m, whereas four had been placed second, and only the eight were in third place. Three women crews decided their races in the last 500m (finish). From the above it become clear that the winning crews judged their potential for performances correctly and managed their race tactics in different ways.

An analysis of the races of winning and second place crews clearly shows that the former have a higher and more consistent boat speed over the entire distance of the course. The wining performance was not achieved through higher rating but primarily through a higher stroke efficiency, i.e. the distance covered per stroke. Winners showed both greater economy (i.e. the ratio of rating to stroke efficiency) and performances of their movements. Both are reflected in the consistency of their second, third, and fourth 500m stretches (Figs 1 and 2). The higher ability to perform allows them a more offensive tactics during the start phase.

Figs 1 and 2. Race profiles of male (Fig 1) and female (Fig 2) rowers at the 1988 Olympics. The graphs show boat velocity (m/sec; top), stroke efficiency (m/stroke; middle), and ratings (strokes/min; bottom) for the four 500m stretches of winning (solid line) and second placed (broken line) crews. Results represent the averages of all boat categories.

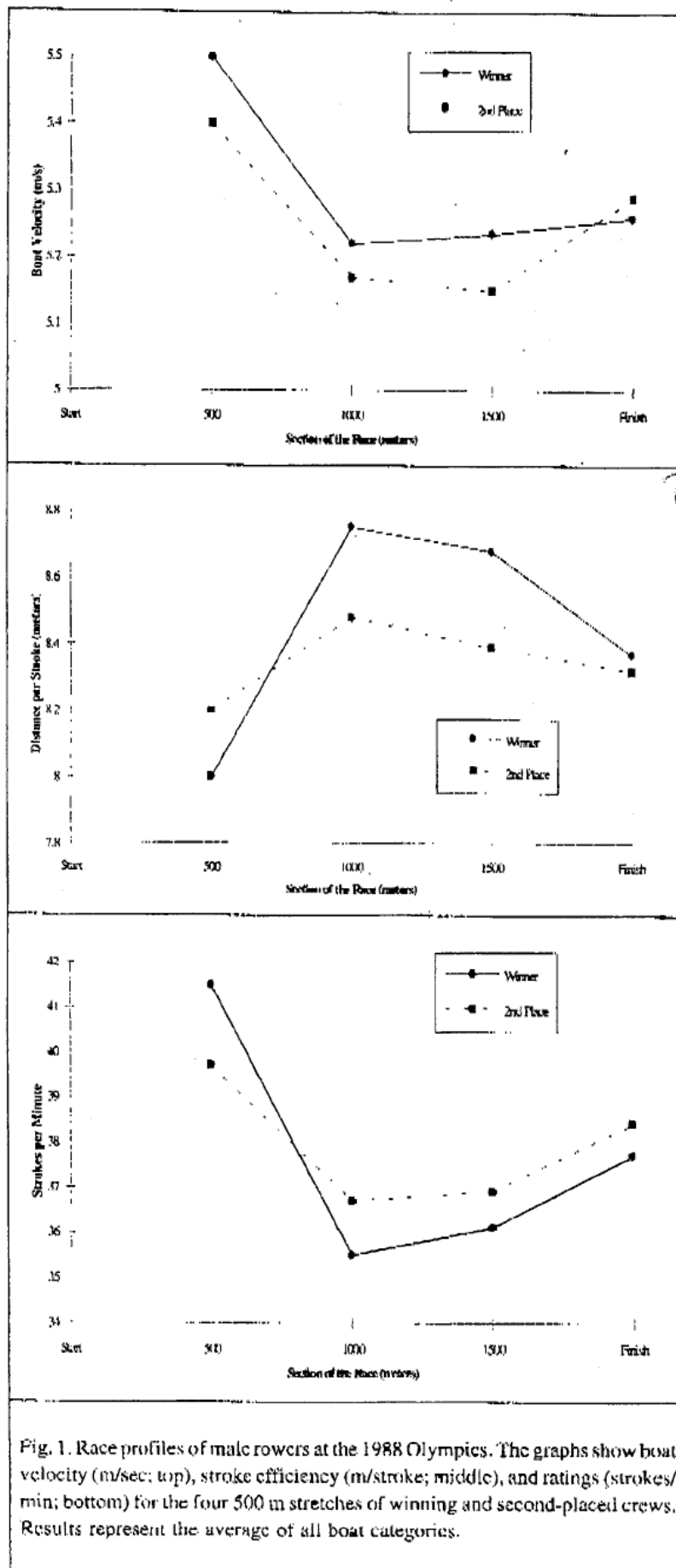


Fig. 1. Race profiles of male rowers at the 1988 Olympics. The graphs show boat velocity (m/sec; top), stroke efficiency (m/stroke; middle), and ratings (strokes/min; bottom) for the four 500 m stretches of winning and second-placed crews. Results represent the average of all boat categories.

2. Factors determining performance in competition

The competition expresses the complex potential of each athlete to perform. The goal of training is to prepare for the race. We distinguish four main groups of performance determining factors for rowing competition:

- personality
- general and specific fitness
- coordinative abilities and technical skills in rowing
- tactical abilities

Personality

During training as well as racing all actions are regulated consciously. The athlete has to have a clear understanding of what he is aiming for and has to be able to realize those ideas. The contents of his aims need to be well understood and his actions require consistency. The needs on the personality profile rises with the goals.

General and Specific Fitness

Rowing belongs to the category of strength endurance sports as the 2000m takes between 5.30 and 8 min and about 210-240 strokes at an average rating of 30-38 per min. With its high demand on strength during the drive (about 500 Newton (N) per stroke) and a workload of about 1100-1200 Nm/sec, rowing at the top level is a sport requiring well developed sub maximal physiological capacities. The special fitness abilities relevant to rowing include:

- (i) specific ability in strength endurance such as aerobic, alactic and lactic capacities
- (ii) Maximal strength during the drive
- (iii) Specific maximal strength of main muscle groups (arm flexors, hip and back extensors)
- (iv) Specific strength endurance abilities of the main muscle groups
- (v) Specific strengths of antagonists

The different stages of a race impose specific and differentiated demands on the fitness of athletes. Tasks, contents and proportions of the fitness training are given by the demands of a rowing race, whereby the extent to which one can train these abilities, their orderly relationship, as well as the relative importance of the various conditions for performance have to be considered.

Coordinative abilities and technical skills in rowing

If the rower wants to achieve exceptional results in competition he/she has to have consistent and well established coordinative abilities. For practical reasons these include skills that are determined by technique:

- (i) the acquisition of a highly efficient rowing technique to reach maximal acceleration per stroke under conditions of sub maximal work load as in a race
- (ii) the consistency in the repetition of the rowing movement in training and races with varying ratings or changes in external conditions such as wind, waves and current
- (iii) a certain flexibility in rowing technique necessary to change boat category or tactic for different races.
- (iv) Using the individual structure of movements within a certain boat (category), i.e. the choice of seating of each rower within a boat to maximize the performance of the crew.

The results we are aiming for in a rowing event demand technical skills from a rower enabling him/her to use all trained abilities (fitness) for the most efficient acceleration of the boat.

Tactical abilities

In the light of the steadily growing density of performance in rowing competitions, race tactics and the tactical behavior of athletes becomes increasingly more important. Tactics in this context means goal-orientated and efficient ways of planning a race.

3. The choice of training means and methods based on the physiological analysis of rowing races.

A rower utilizes three different energy providing metabolic pathways during a race:

- 1) the anaerobic – alactic metabolism – at the start which covers the first 10 strokes
- 2) the anaerobic – lactic metabolism after the start covering the following strokes for up to 60-90 secs; and
- 3) the aerobic metabolism predominant from about the second minute to the end of the race.

These different pathways of energy production are not separate metabolic events. Rather, two or three different forms of energy supply are generally operating at the same time during a work out. The relative percentage of the different energy supplies involved depends on the type of competition and the training condition of the rower. To examine the performance of the rower we normally use the level of lactate as a parameter for anaerobic lactic capacity, and the oxygen intake (VO_2) as a parameter for aerobic capacity. According to physiologists, the fast twitch fibers (FTF) are used only partially, i.e. at the start. In contrast, the contribution of slow twitch fibres (STF) as the biological and structural correlate to strength endurance, dominates during the main part of the race – especially in the middle stage (=85 – 90% of the entire race time). Therefore, rowing performance is mainly based on STF and strength endurance. In general the percentage of STF in rowers is 70-80%.

Glycogen and triglycerides (fat) stored in muscle cells represent the most important substrates for the energy supply during a rowing race. Although glycogen is the main energy substrate in muscle cells it does not normally limit performance. Glycogen is utilized as an energy substrate especially during the first third of a race. This can be seen by the levels of accumulating blood lactate, the end product of anaerobic glycolytic metabolism. The increase in blood lactate concentration is greatest during the initial phase of up to 90sec.

Triglycerides – especially those in STF – decrease gradually during the first third and more rapidly during the middle of a race. They partially contribute to the overall energy supply as an energy substrate. Therefore, even when working at maximal capacity during a race, and a stage where medium term endurance is required, rowers are still able to make use of the well adapted fat utilization system as a source of energy. Hence, elevated cellular levels of glycogen and triglycerides within the muscles are an essential energy requirement for competition.

From physiological parameters such as oxygen consumption, heart rate, blood lactate, and respiratory indices, it is possible to draw qualitative conclusions regarding the relative contribution, relation and importance of the various energy supplying components during rowing races. Oxygen consumption as an index of aerobic energy supply reaches its maximum value of 5.5 – 6.5 l/min (steady state) 1.5 – 2 min after the start. The tidal volume (volume of air breathed in) behaves in a similar way, while the heart rate plateaus at its maximal level (between 180-200 strokes/min) 3-40 sec after the start (Fig 3)

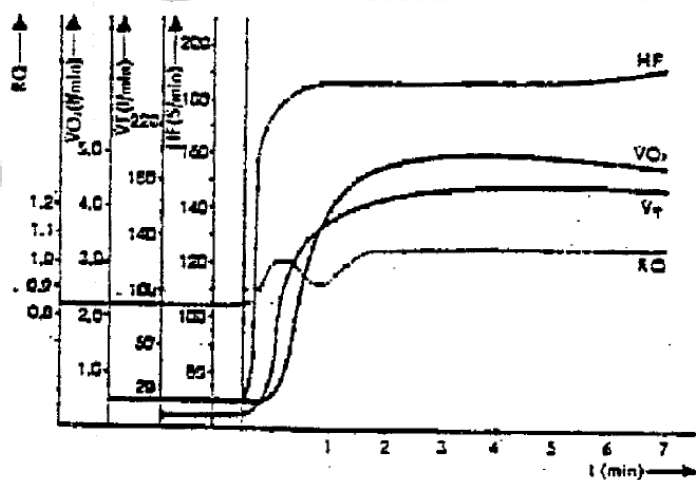


Fig. 3. Time-dependent changes in heart rate (HF), oxygen consumption (VO_2), tidal volume (V_T), and respiratory quotient (RQ) during a simulated rowing race of maximal intensity.

The rate of oxygen consumption clearly shows that the energy supply required is covered mainly by (i) alactic and lactic metabolism during the first 1.5-2 min and (ii) aerobic metabolism during the middle and

final stages of the race. Therefore, the race speed during the middle stage is determined mainly by the athlete's aerobic capacity.

Oxygen consumption is a useful parameter representing the oxygen transport capacity of the respiratory and cardiovascular system. To use the oxygen transported for energy supply, the aerobic metabolism of glycogen and triglycerides within the muscle cells has to be increased through adaptation. As the muscles capacity to use oxygen and the energy required for general movement differ from one person to another, rowers with identical maximal oxygen consumption can have differing sporting performances.

The behaviour of lactate accumulation under racing conditions is of great importance for the planning of training,

In general, physiological analysis reveal that during a race the degradation of glycogen with concomitant accumulation of lactate operate at maximal speed after an initial period of 5 – 10 secs and reach a maximum within 40-60 secs. While oxygen consumption sunsequently increases, the production of lactate decreases sharply. It reaches its lowest rate in the last part of the middle stage before increasing again slightly during the last few strokes. As shown by the curse of blood lactate levels in Figs 4, 5, and 6, and especially by curves 2 and 3, the energy supply

- (i) during the first 10-15 sec of the race, i.e. the most demanding part of the entire race (acceleration phase at the start), is covered by alactic metabolism (Feldberg, 1963)
- (ii) in the second phase of the start (phase of maximal speed and, to some extent, transition phase to the middle stage) is predominantly lactic
- (iii) during the concluding stages of the race still includes some lactic metabolism, however to a lesser degree.
- (iv)

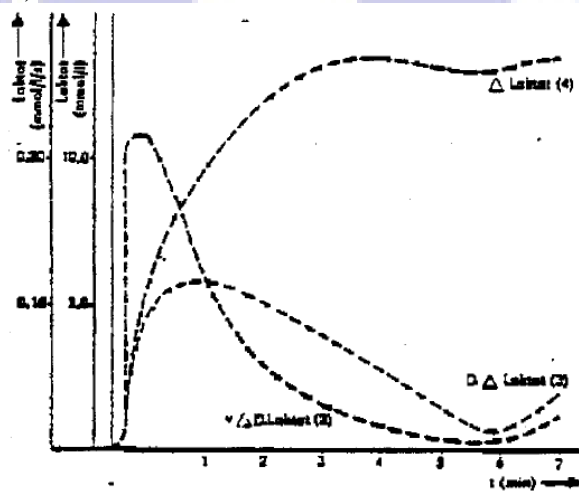


Fig. 4. Time-dependent changes in blood lactate levels (mM) during a simulated rowing race of maximal intensity. Curve 2: changes in velocity (v) of accumulation of blood lactate (mM/sec) calculated from the differences in lactate concentrations between various time points of the work load. Curve 3: absolute changes in lactate concentrations calculated between various time points. Curve 4: total blood lactate (the amount of lactate present at rest has been subtracted).

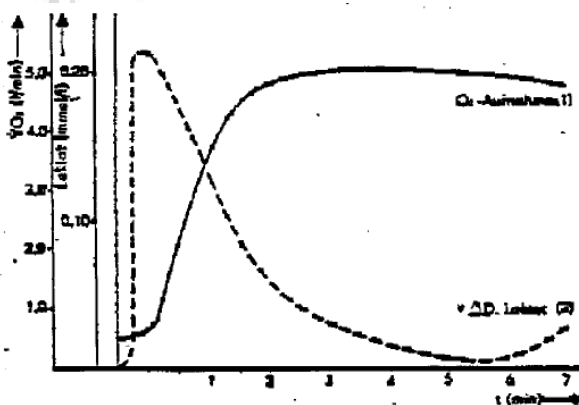


Fig. 5. Time-dependent oxygen consumption (curve 1) and velocity of accumulation of blood lactate (curve 2) during a simulated rowing race of maximal intensity.

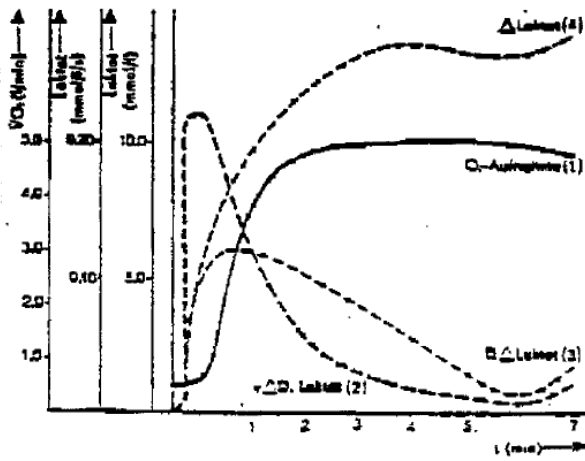


Fig. 6. Time-dependent oxygen consumption (curve 1), velocity of accumulation of blood lactate between various time points (curve 2), absolute changes in lactate concentrations calculated between various time points (curve 3), and total blood lactate accumulated (curve 4) during a simulated rowing race of maximal intensity.

The absolute levels of blood lactate achieved during maximal work in a race are influenced significantly by the rower's aerobic capacity. Fig 7 shown a comparison of absolute lactate concentrations in the blood of rower(s) with high (curve 1) and poor (curves 2-4) aerobic capacities. As can be seen, blood lactate in rowers with poor aerobic capacity, increases early and steeply, reaches its maximum level during the race (curve 4) and cannot be elevated further at the finish of the race.

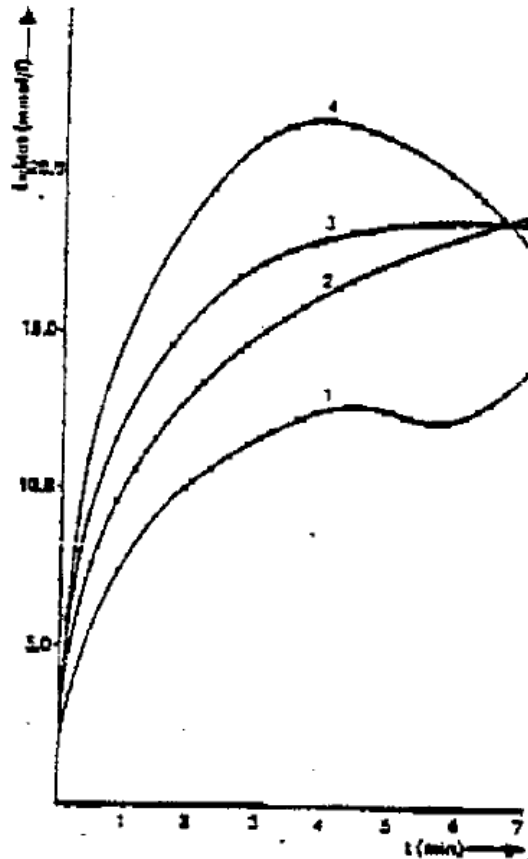


Fig.7. Blood lactate levels (accumulation and absolute levels) of rowers with different aerobic capacities during a work load of maximal intensity simulating that of a rowing race. Curves 1 to 4 represent typical results obtained from rowers with decreasing aerobic capacities.

Early and high concentrations of lactate in muscles diminish their aerobic production of ATP within mitochondria (power plants of the cell), regeneration of creatine phosphate, glycolytic efficiency, contractibility, and neuromuscular coordination. Because of these biological relationships high concentrations

of lactate limit strength endurance and coordinative abilities which are the performance determining conditional abilities in rowing.

The time dependent contributions of aerobic and anaerobic components to the overall energy supply is related closely to the course of performance and oxygen consumption. Thus, between the first 10 and 90 sec of a race i.e. when the physical output reached its highest level, the energy required is covered mainly anaerobically with a contribution of 78.9 at the 10 sec point and 46.8% at the 90sec elapse point. The corresponding oxygen consumptions at these two points are 42.8 and 88.7%, respectively. These percentages can be contrasted to the maximal oxygen consumption achieved at lower stages. The high oxygen deficit produced in the first stages of a race needs to be compensated by an equivalent supply of anaerobic energy.

Oxygen consumption reaches a relative steady state only after the second minute of a race. At this stage, the energy required for an almost constant physical output is covered 84% through aerobic means. However, it becomes clear from Figs 8 and 9 that the overall energy requirements generally exceeds the total energy capacity, and therefore are dependent on additional, continuous alactacidic or alactacidic energy supply.

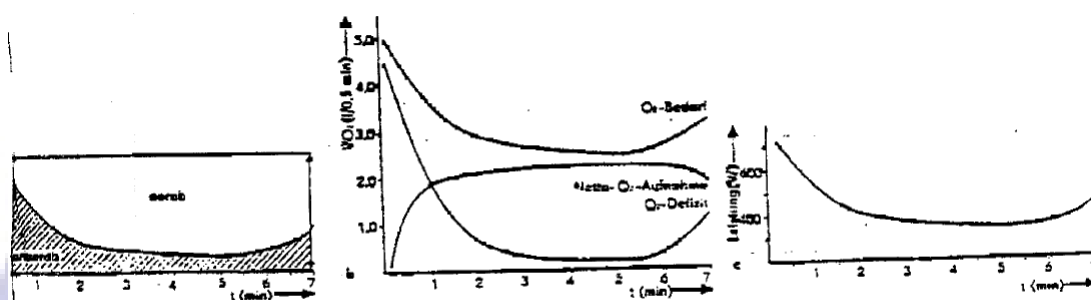


Fig. 8. Time-dependent, relative contributions of the anaerobic and aerobic components to the overall energy requirement (a); the oxygen requirements, net oxygen consumption, and the resulting oxygen deficit (b); and the basic profile of performance (Fig.c) during a simulated rowing race of maximal intensity.

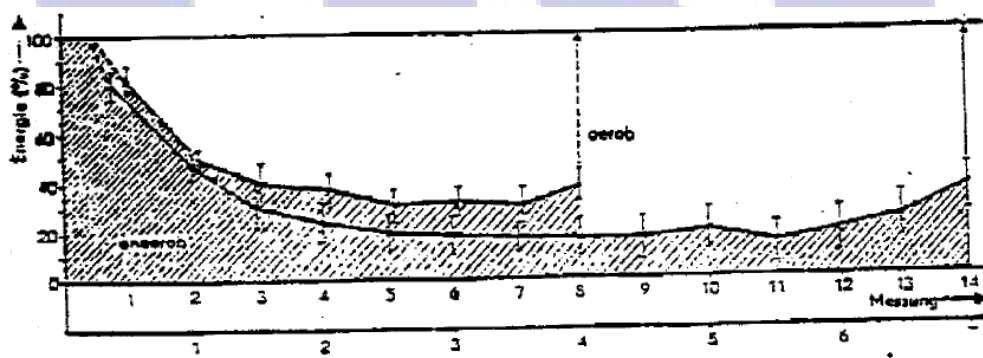


Fig. 9A. Time-dependent, relative contributions of anaerobic (hatched) and aerobic (open) energy supply during rowing competition of maximal intensity for men (bottom curve) and women (top curve).

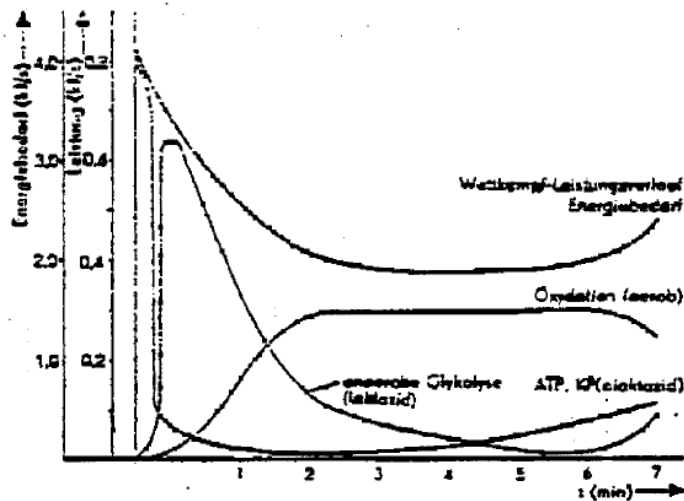


Fig. 9B. Time-dependent, quantitative and qualitative changes in energy supply during a physical workload (expressed in $\text{kJ} \approx \text{kNm/sec} = \text{kW}$) similar to that in a race. The graph shows the relative contributions of alactacidic, lactacidic, and aerobic energy components. Note that this is a semi-quantitative figure, and that the energy requirement is based on an efficiency of 20 %.

Although the rower tries to exploit anaerobic capacity to its full extent during the final stages of a race, the remaining output derived from it is relatively small especially if the demand for anaerobic energy was high during the start phase.

Fig 10 shows the relative contribution of each energy component to the total energy supplied during the race. The columns represent the situation at the end of successive time periods during a race and hence show the change in relative importance of the different energy components depending on the length of a rowing event. Time periods were 0-20, 0-90 sec, 0-4, 0-6 and 0-7 min (racing time in a rowing event)

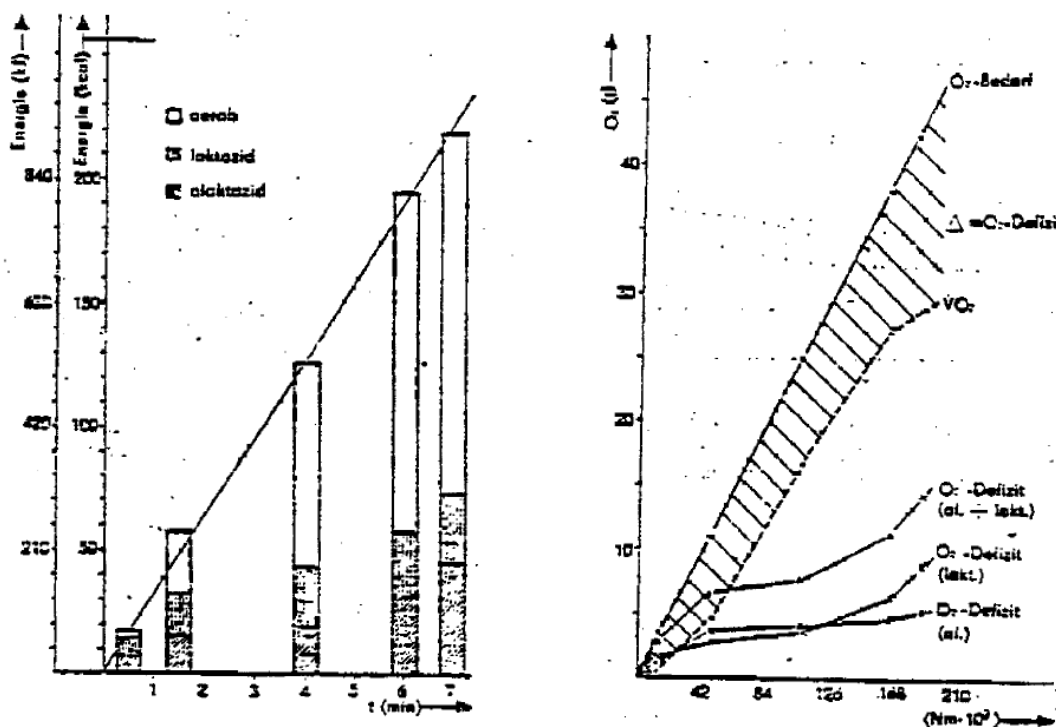


Fig. 10. (Left) Time-dependent changes in the absolute contributions of the different energy components during a simulated rowing competition of maximal intensity. The result shown at 7 min represents the contributions of the various energy components to the total energy supply required for a rowing race. In each column the aerobic, lactacidic, and alactacidic component is shown as top, middle, and bottom part, respectively. (Right) Workload-dependency of oxygen requirement (●, solid line), the oxygen actually consumed (○, broken line), and the resulting oxygen deficit (hatched area) during a simulated rowing competition of maximal intensity. The oxygen deficit is expressed in its total (x, top), lactacidic (x, middle), and alactacidic (x, bottom) components. The result shown at $209.5 \text{ Nm } 10^3$ is representative for a rowing race. Note that all results represent mean values.

For an event of 7 min duration (corresponding to a 2000m race), the total energy requirement average 70% aerobic and 30% anaerobic. The aerobic portion is comprised of 10% lactic and 20% alactic energy supply. The aerobic and alactacidic energy supply together contribute about 90% of all performance determining, physiological components. Considering quantitative aspects, these two components must be the main determining factors for competition (Fig 11)

To logically deduct adequate training methods in an aim oriented manner, knowledge of the temporal changes of contributing energy components to the overall energy supply of a competitive workout is needed. In addition, their relative contribution must be considered to develop all biological systems involved.

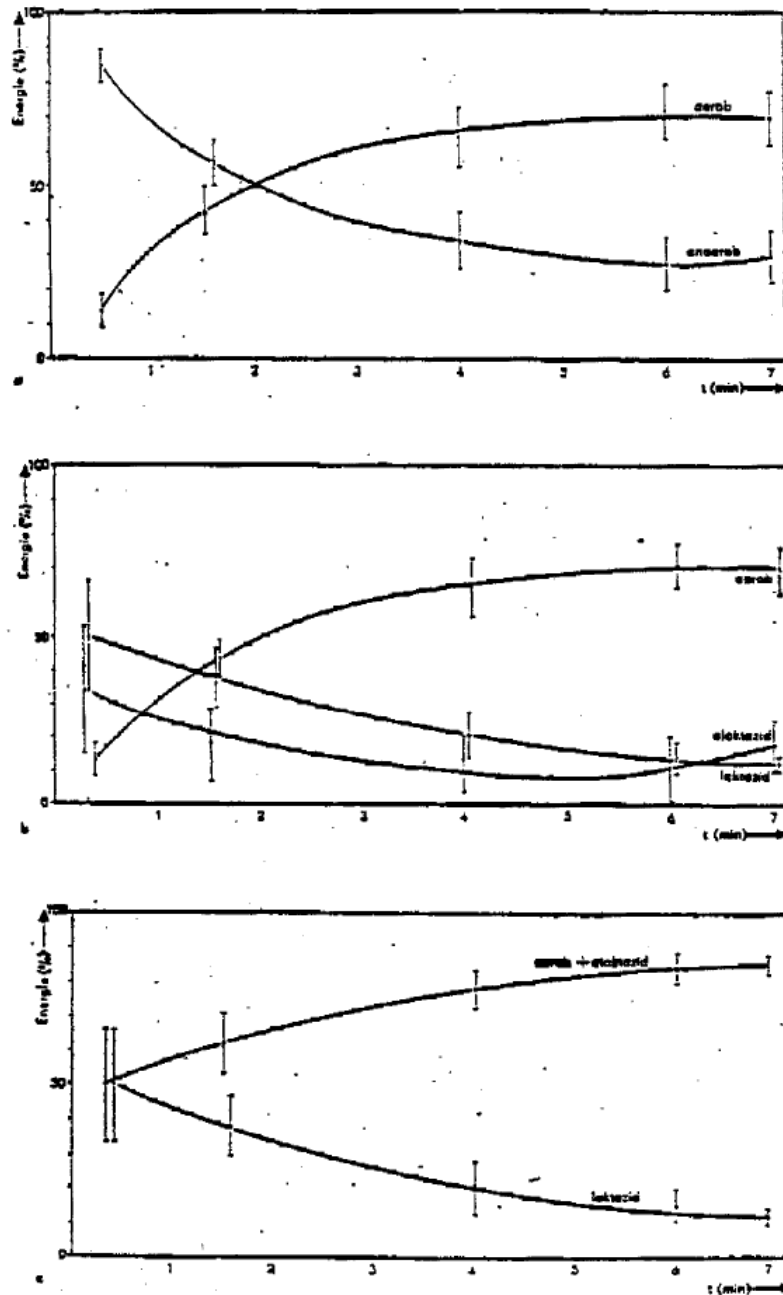


Fig. 11. Mean contributions of energy components to the energy supply in relation to the duration of a simulated rowing race of maximal intensity. a, aerobic and anaerobic energy components; b, aerobic, alactic and lactic energy components; c, sum of aerobic and alactic energy components and lactic component. The different time periods indicated are 0 - 20, 0 - 90 sec, 0 - 4, 0 - 6, and 0 - 7 min. At 7 min the percentage of energy components for the entire race is shown.