


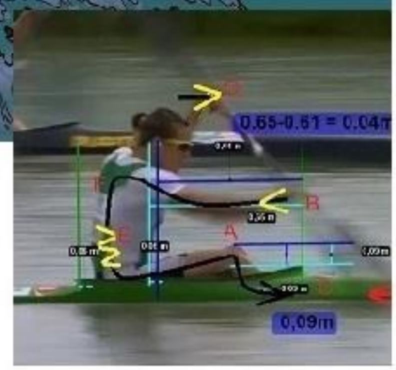


# ANDREA PACE

# Complements to the Base Technique in Sprint Kayak; Methods of Evaluation

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**What you can read bellow is only the first 19 pages – the introduction to the book.**

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# Complements to the Base Technique in Sprint Kayak; Methods of Evaluation

## Summary

The following is a study on the methods of evaluation of complementary elements of Base Technique. These are:

1. **Meta-Technique** – which represents the athlete's primary objective and is closely related to the hydrodynamic characteristics and the statistical necessities of energy exchange; and
2. **Micro-Technique** – which relates to the specifics of force application with a view to achieving the desired objectives, using Base Technique as required.

We will also be examining the physical principles relating to the various evaluations, as well as providing the formulae and showing the methods of video-analysis employed.

With regards to the athletes' Meta- and Micro-Techniques, we shall evaluate some of the elements identified in the video clips. An athlete with flawless technique will produce physical phenomena that leave predictable and consistent traces, which in turn represent the optimal point of reference. It is not a coincidence that these traces and phenomena correspond to the principles of propulsion of naval hydrodynamics. On the other hand, an athlete whose technique is imperfect will produce physical phenomena that leave chaotic traces, which are never similar to those we expect to see in optimal cases.

We will also devote our attention to analysing races using GPS data for speed and frequency provided by the ICF (International Canoe Federation) and by the FISA (Fédération Internationale des Sociétés d'Aviron) for international races. It is possible to obtain a great quantity of information using said data: we can analyse information relating to quality, as well as indicating the fundamental 'methods' or 'modes'. We will see how the 'methods' used by champions correspond to those predicted by theory, whereas the 'methods' used by lesser-skilled athletes make no sense when viewed from the point of view of hydrodynamic propulsion.

Throughout this paper, I will be conducting qualitative studies of athletes' technique. When an athlete stops improving, the root of the problem often lies in a technical issue that hampers the process of optimisation. This is made evident by the studies conducted on many athletes who compete on an international level. Unsurprisingly, the qualitative behaviour of athletes who only compete on a national level will be even worse. Trainers will find H-Graph-based analysis particularly useful when training athletes who have stopped improving: in the space of just a few minutes, it will become clear whether or not there are technical issues. Once this has been established, one must then proceed to deal with the issues by solving them and ultimately finding a way to benefit from them.

# Foreword

Notes for the reader:
The introduction (**Chapter 0**) can be rather difficult to understand, even for those of you who are familiar with the topics covered. I therefore advise you to either take a leap of faith, and proceed directly to the questionnaire or to **Chapter 1**, or to choose to attempt to study and comprehend the reasons behind the choice of the selected methods.

The term *stiffness* is used here to indicate the ability to resist elastic deformation due to an applied force. Athletes described as ‘contracted’, or ‘rigid’, means they are experiencing difficulty with one or more joints, with the muscles blocking the movement. In this case the movement is inelastic and the joint is unable to return the energy it has absorbed. Trainers should, instead, try training the athlete to uphold a harmonious and elastic behaviour, with the right amount of deformation proportionate to the load. This means having the right *stiffness*: stiffness = deformation / applied force.

For instance, in case of a ‘well-fixed’ joint, the stiffness value becomes very high. In this way, for example, the blocking of the shoulder girdles is determined at the very first stage of contact with water. If this is not done, and the leg muscles proceed to apply maximum strength, the athlete will most likely experience muscular contraction and ensuing myofascial damage. A lay observer may think that the athlete is too rigid, whereas the latter must instead simply determine the weak link correctly, and do so in a more rigid way – indeed with more stiffness in that joint. It is important to understand the subtle ambiguity of the terms ‘rigid’, or ‘stiff’ in order to avoid incorrectly training an athlete with stretching exercises when the primary cause of concern is actually an inability to block, which could be fixed by undergoing appropriate weight training exercises.

A further issue lies in the definition of the terms *efficiency* and *effectiveness*. In this context, an action is ‘efficient’ if it is carried out with minimal waste. It is calculated by looking at the relationship between applied power and necessary power. Efficiency is the decisive element in long-haul races.
On the other hand, an action is ‘effective’ where the interaction of the various components leads with increased ease to the achievement of a result. Effectiveness is decisive in shorter races, where a significant waste of energy can be justified if it means that time can be reduced even by just a tenth of a second. A clear example of this is the use of the legs in freestyle swimming – in longer races legs are not used very much, whereas in shorter races they are used much more, albeit for the purposes of an advantage in terms of time that is small when compared to the expense in terms of energy.

# Contents

# Chapter 0: Physical Phenomena Concerning the Relevant Evaluations and Questionnaire

Throughout this paper we will deal with the evaluation methods and the primary aims of technique. The issue of stiffness, instead, is part of the smaller details that make up the overall motion. This topic is mentioned at **paragraph 0.4**, and leaves scope for extensive research.

With regards to the various references made throughout the rest of this paper, these represent material gathered in consultation with Mr Carlo Vivio (*01) and Mr Jernej Župančič Regent (*04), who have a particular way of preparing these small yet crucial details, by making use of original exercises both in and out of water.

Contrarily to the theory, evaluation methods are very simple: in some cases they consist of just one single frame from video footage, upon which are traced coloured segments and numbers representing the differences between two or more athletes.

Unfortunately, focussing solely on a single criterion of assessment without knowledge of the whole theory and its relationship to other methods, may result in this research being perceived as an arbitrary process that leads to merely distinguishing some athletes' technical qualities.

We must, however, be patient: in deciding to avoid the formalism of physics, mathematics and hydrodynamics itself, we must accept that any phenomena corresponding to a theory can only be confirmed by methodical observation. A thorough reading of the whole document will demonstrate how lesser-skilled athletes obtain worse results on all evaluation criteria, and that the only athletes with perfect scores are Adam Van Koeverden in the K1 1000m in 2011, and the Croatian double sculls, the Sinkovic Brothers (in every appearance). In order to verify this yourselves, you can view the footage from Van Koeverden's London 2012 races – it is clear he no longer upholds the same behaviour in terms of quality, and, as a consequence, he comes in second and not first. For a trainer this may be sufficient, but it can be very time-consuming to read the material, read it again, watch the clips, and make up one's own mind.

Should you encounter a section with far too much information to be comprehensible, but also far too interesting to be left uncomprehended, please feel free to email me with your views and/or questions at **andreapacez@gmail.com**

The race model is displayed on a graph that can be quite challenging to make sense of. The graphs follow tables that display the corresponding data. In any case, these graphs will become easy and fast to consult once it is understood how they operate. All it takes is an investment in terms of time, and some initial blind faith.

The following is an example of a simple problem with a complex solution. Around 20 years ago, in 1996, several other trainers and I observed the movement of Holman's and Rossi's legs. The fact that, right at the beginning, the athletes' knees were virtually at the same height appeared to contradict the importance of legs in relation to propulsion.

**Fig. 5.4** (**Chapter 5**) shows one of the athletes with the absolute ideal leg movement, namely Marko Dragosavljevic. He not only moves the knee of the 'counterforce' leg, but also lowers the other knee: this is already happening 3 frames (or about 0.05 seconds) before the paddle touches the water. This shows how all the elements of Micro-Technique, usually performed unconsciously, such as muscle preload, blocking, elasticity and trajectory handling, must be managed in a stable manner in all racing conditions.

This topic is widely ignored in the context of Base Technique, and, in fact, there are still no clear answers to the questions posed 20 years ago. Such a simple technical element like the synchronicity between the movement of the legs and the motion of contact of the paddle against the water is not acknowledged either in scope or with regards to the frame-by-frame differences of anticipation and delay of the single leg. Yet this phenomenon leaves '**clear traces**' on the clip.

I am sure there have been people who, decades ago, were asking themselves the same questions: indeed, a lot of athletes and teachers (for example, Dario Fogo), even more inquisitive than I, have guided and encouraged me in pursuing my research.

With regards to this matter I must add that many trainers are induced to think that athletes such as Pimenta and Stuart tend to under-perform in the final part of the 1000m races due to metabolic characteristics. There exists, however, the definite possibility that there is a breakdown in performance due to errors that, in conditions of fatigue, can no longer be compensated. In **Chapter 4**, we will analyse the races of two athletes whose performance issues are undeniably of a hydrodynamic nature.

## 0.1 – Meta-Technique

Technique can be separated into three parts.

### 0.1.1 Base Technique

The term Base Technique indicates the way in which the four stroke phases (preparation, attack, traction, and exit) are applied as determined by the trainer. This system, albeit being necessary in many water sports, is in itself not enough. If Base Technique is used alone, the athlete remains free to perform numerous actions with all parts of his body. This can only lead to a positive result for athletes who are naturally endowed with those skills that are not required by Base Technique; those skills that trainers cannot transfer to their athletes precisely because of the Base Technique's limitations.

From the athlete's point of view movements are performed subconsciously, using a mix of harmony, aquaticity and sensitivity. In this context, these terms have the following meanings:

1. *Harmony* – how the cyclical paddle stroke movement is performed and whether it is in harmony with the cyclical movement of the boat and the elastic elements of the human body and of the paddle itself;
2. *Aquaticity* – the ability to deal with the water surrounding the paddle;
3. *Sensitivity* – the ability to deal with muscular tension in the body and in contact with the equipment.

We must further consider that, in conditions of fatigue, certain elements – such as variations in available strength, stiffness, and synchronism – cause diverse propulsion trajectories, and this can lead to a rapid loss of efficiency and effectiveness in the movement.

## 0.1.2 Meta-Technique and Micro-Technique

The term Meta-Technique defines what are mainly hydrodynamic, mechanical and thermodynamic phenomena without which it would not be possible to obtain satisfactory results.

Micro-Technique, on the other hand, refers to propulsive muscular interactions coupled with muscular interactions relating to the harmonic equal distribution of energy.

Using the evaluation systems shown in the paper, we cannot observe and understand the physical phenomena of Meta-Technique, but we can measure its effects. We shall see in detail that these methods represent a system of evaluation that is both qualitative and quantitative. This system is tantamount to observing the tracks left by an invisible giant, i.e. physical phenomena we cannot see directly until the moment they become evident.

Some trainers have no need for this information, as they have the ability to choose the best angle to observe one phenomenon at a time. In this respect, observing some video footage of Nikola Bralic (CRO), I have become convinced that he would have no need to study the present paper. Indeed, his best crew (M2x Sinkovic Brothers) is currently being used as the point of reference to construct this entire method.

Some trainers correctly apply Base Technique and give the athletes a wide freedom with regard to all the rest, selecting capable athletes who already possess the necessary complementary skills.

The purpose of this paper is that of systematically utilising knowledge of Meta-Technique and Micro-Technique to ensure the success of lesser-skilled athletes, and likewise helping the more capable ones to adapt to new crews or to different-length races.

Other trainers, instead, use systems that are simply incorrect, for example adding extra details to the Base Technique and doing so in the wrong order. In this way, one may miss the chance to bring out natural talents.

We will see further on how the optimisation of a coefficient of naval hydrodynamics, known as the *coefficient of advance*, crucially affects Meta-Technique.

## 0.2 – The Equilibrium between Inertial Masses and the Dispersion of Energy

One element of Meta-Technique that is not too closely tied to hydrodynamics is the equilibrium between the opposing masses on the points where strength is applied. In kayaking, the way in which athlete apply force is subordinate to this task. The dispersion of energy in the case of disequilibrium is a 'statistical thermodynamic necessity', and energy is always absorbed by the point with the least inertia.

In the next few paragraphs, we shall see how water inertia and athlete inertia are balanced by modifying the length of certain levers. In addition to perfect balance, we might encounter two situations:

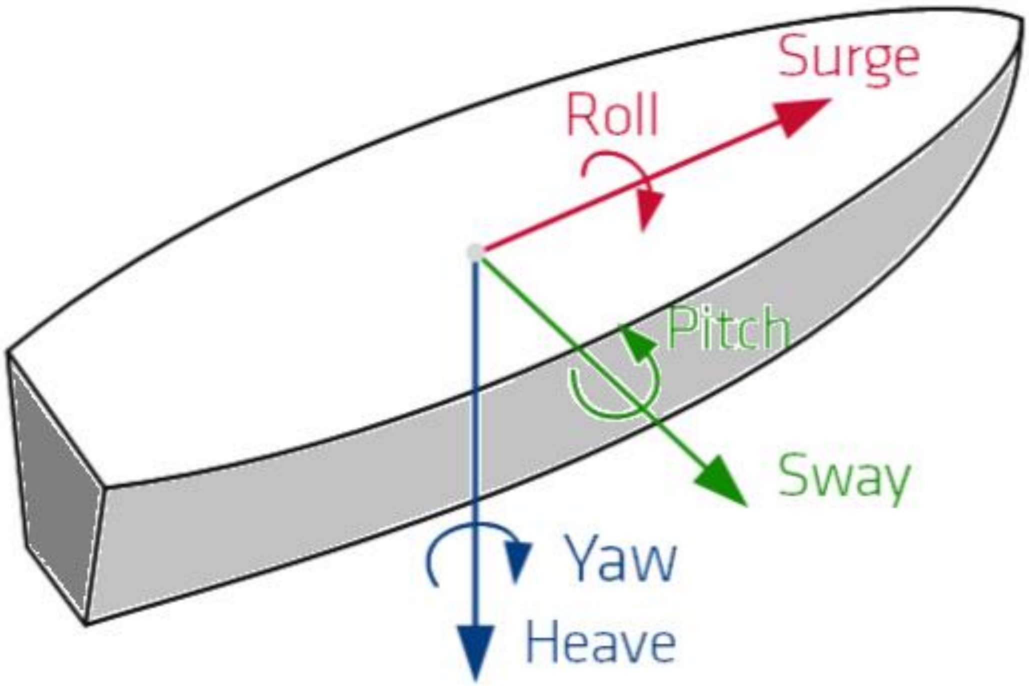
1. Where athlete inertia prevails, and there is a dispersion of energy in water with ensuing turbulence; and
2. Where water inertia around the paddle prevails, and there is a dispersion of energy in the athlete's body, more specifically in the muscles and/or connective tissues.

This type of information is crucial in order to be able to correctly regulate the boat settings in both rowing and kayak.

It may sound like a paradox, but it is precisely by increasing the inertia on which the force is applied that energy is dispersed within the athletes' muscles. This is a positive note for muscle hypertrophy training. However, when athletes fail to correctly set up the weak elements of the chain of force transmission, the dispersed energy damages the myofascial system. The result of this is that the production of testosterone is not stimulated, but the production of cortisol – testosterone's biggest enemy – is.

## 0.3 – The Cornerstone of Meta-Technique

The motion of the boat represents the cornerstone of all athletic movement in water sports. Moreover, it is the most important and sensitive element in Meta-Technique evaluations. This can also include swimming, if we consider a human body as a boat. Fundamentally, it is based on the assumption that if this element is optimised first, the rest will smoothly. Below, I will demonstrate this 'strange' phenomenon from the points of view of theory and naval propulsion.
The boat motions, as shown in **fig. 0.3**, are as follows:




[Fig. 0.3]

1. *Rotational motion*: roll, pitch and yaw; and
2. *Translational motion*: surge, sway and yaw.

The second element of Meta-Technique is water interaction. While this element is being optimised, the appropriate boat motions can easily be maintained precisely because they facilitate the correct interaction with water.

Finally, we will deal with the transmission of strength throughout the body. Once we get to this stage, we will have already optimised hydrodynamics, and we can concentrate on maintaining a balance of inertias, of the forces, and torques at play on the points of support. When put into practice this means that, if we develop strength and transmission abilities in accordance with principles of Meta-Technique, we will not run the risk of making mistakes.

## 0.4 – The Inertial Machine

When athletes learn technical movements on an ergometer, the results can be random. This happens for several reasons, the main ones being that:

1. The balance of forces is completely different to that of kayak; and
2. The balance of masses becomes impossible since, when using an ergometer, the legs' counter-mass is infinite, whereas on a boat the counter-mass is the weight of the boat itself. Moreover, the upper body's counter-inertia is represented by the ergometer's flywheel, which remains fixed and equal throughout, whereas when the athlete is on a boat the upper body's counter-inertia depends on the use of the paddle or oars.

Please see **Chapter 5** – where we will be discussing radii – for another preview on how the experience of training on an ergometer differs from that on an actual kayak. The use of a mobile cart as opposed to the braking part of the flywheel is essential to deal with inertia on contact with the feet, but it is necessary to build a regulating system that deals not only with the braking power but also with the flywheel's inertia.

With regards to the selective learning of technique – separating each element one by one – it is much more convenient to use a system similar to the ergometer which, however, allows the athlete to exercise his or her strength at will on the appropriate inertia with both arms and legs. This topic will be further discussed in a future publication that will introduce the balanced and harmonic elastic inertial machine.

## 0.5 – Advance Coefficient J

The most important aspect of any water sport is propulsive yield. In this respect, there are two fundamental notions:

1. Each propulsor has a maximum hydrodynamic efficiency level with a precise advance coefficient, shown with the letter 'J' in naval hydrodynamics. J is proportional to the advance per stroke when the percentage of time spent in water is constant (see **Chapter 5**); and
2. The inertia of the water mass involved in the action, which stabilises the grip of the water, is proportional to the radius to the power of 4.

The geometric equivalent of the advance coefficient J is the angle of incidence of the water on both sides of the paddles.

A kayak's pitch motion is usually limited to 1 or 2 degrees of rotation. The surge motion is not oscillatory but becomes cyclical thanks to the movement of the athlete's body. Both motions greatly influence the advance coefficient J. The angle of incidence of the water on the paddle – put simply, the way in which the paddle slides in and out of the water as it undergoes the propulsive action – will change significantly according to the synchronisation with the boat's motions. As mentioned in **para. 0.3**, we must first deal with these motions by synchronising them with the propulsive action, and then proceed to optimise the propulsion phase.

A clear example of when the procedural order is crucial could be a person who has to regulate the rear-view mirror of their car, and has to use a padded cushion in order to sit in a more ergonomic position.

In such a case:

1. The correct decision would be to position the cushion first, and to then adjust the rear view mirror accordingly;
2. The incorrect decision would be to proceed in the opposite order.

To complete the analogy with **para. 0.3**, the cushion would represent the cornerstone of this system.

As will be made clear in **Chapter 9**, there are several procedures that need to be completed in a precise order, starting from the boat and moving on to the paddle, and, finally, to the transmission of force.

Regarding the transmission of force, we can compare it to a musical instrument:

1. First we have a pianoforte, representing the 'completeness' of an athlete in a kayak;
2. Second we have an electronic keyboard, with particular attention given to the keys (touch-responsive): this corresponds to paddle on a boat which moves at the same speed as a kayak, but that is blocked in all its linear and rotational oscillations; and
3. Finally, we have a keyboard printed on a piece of paper: this corresponds to an ergometer.

What this means is that, when using an ergometer, one must not make the mistake of thinking that they have mastered the final skill, when, in fact, training on an ergometer is merely a technique used to isolate and fix specific problems athletes may be experiencing. A pianist can execute the Base Technique perfectly on piece of paper, and at the same time press his fingers against the printed keys with different speed, force and impulse for each note. He can afford to do this because he receives no feedback regarding the sound variations in volume and timbre.

This can be positive if the instructor means for the student to concentrate on only one detail, but it can become a problem if the student then automatically perseveres in carrying out the flawed actions that they were unable to dominate on ergometers. Similarly, a kayaker or rower can take advantage of the fact that ergometers are fixed to the ground – this way, any inertial thrust motion on the footrests will not penalise them, and they can apply greater force without actually gaining any real advantage once on board of an actual boat. Fortunately, in rowing at least, it is possible to make use of the special slides placed under the ergometer.

Whichever system is used to simulate movement in a gym, Meta-Technique is of the utmost importance and athletes must be able to implement it. This can only be achieved on a boat. Elements of Meta-Technique that, to the layman's eyes, may seem almost uninfluential can actually drastically modify Meta-Technique. These are:

1. Changing the vessel: each boat behaves differently with regards to linear and rotational oscillatory motions. In hydrodynamics the fundamental element that affects this dynamic behaviour is the mass added to the boat: basically, each boat's inertia increases proportionately to the mass of water affected by the movement under consideration;
2. Changing the crew's position: in this case also, the equilibrium of forces exercised by athletes in relation to their place on the boat can change dramatically even if the position is changed by just a few centimetres; and

3. Changing the area of water where training is conducted: in some cases maximum speed differences of one second for the T100 have been observed (T100 is defined in **Chapter 5** and it is the time taken to travel 100m at a given speed).

Since these modifications, which may appear trivial, have such significant effects on athletes, we can conclude that simulation devices cannot meet the demands of Meta-Technique.
The first element that must be optimised is the motion of the boat relative to the athlete and the paddle (or the oars). It must be a priority because it directly affects propulsive hydrodynamics: this explains why changing the boat or the crew's position always brings about big surprises.

Let us consider that on a crew boat, when the bow is high, the athletes nearest to the bow are also furthest from the water. This and other similar phenomena can explain why certain kayak athletes and crews obtain better performance with actions that may at first appear to be erroneous – for example, radius, angular sectors and different timing of entry and exit. These represent automated compensations that can lead to good overall efficiency, but may on the other hand limit further improvement. Moreover, when such compensations and sensations lead to success, athletes are unwilling to give them up. In order to improve, therefore, we must understand what error is being compensated by the visible actions and eliminate it.

The second element that must be optimised is the ability to have good water grip. In order to create the right interaction, the blade must enter the water unhurriedly, even at the highest of frequencies. It is always necessary to allow the water around the paddle to create the large mass of slow-moving water that allows the blade to slip upwards out of the water creating a force in the horizontal direction.

The third element that must be optimised can be simplified in Base Technique terms: after the paddle or oars have entered the water, the athlete must continue holding these in the smoothest way, with no tugging or jerking motions, which is what we see happening with the best athletes. We will soon see how inconsistencies can be produced by many factors that are the key components of Micro-Technique. I will be assessing these further on.

All the Macro- and Micro-Technique methods of evaluation have been created for those trainers who want to give their athletes the possibility to improve from a technical point of view. The athletes must acquire the skills they do not have, and at all costs avoid situations where there may be saturation. The use of such evaluation methods remains silent on the topic of how to achieve athletic perfection – this will be our main objective, although we know it is impossible to achieve in a definitive way. These evaluations, therefore, are useful for trainers who have the ability to convey to the athlete the right approach to tackle the diagnosed issues. The problem could be banal, like a paddle that slides in the water, but the solution can be complicated since, as we have seen, we must proceed with order starting from the movement of the boat and, in particular, the relativity of movement between boat and athlete (pitch and surge, **para. 0.3**). Trainers all too often advise athletes to perfect certain details, while neglecting the fact that they must first perfect the base.

# 0.6 – Static and Dynamic Behaviour of Forces Applied to a Lever

When applied to a lever, dynamic actions follow different physical laws than static forces. Static forces in relation to levers have linear balance, whereas in the case of a force that produces displacement, the part of it relative to the acceleration of a mass in a circulatory motion depends on the square of the length of the lever. For complex reasons, the inertia of water interacting with the paddle depends on the length of the lever to the power of 4.

Below, we will proceed to define only the fundamental levers called Radius 1, 2, and 3, together with the advantages and disadvantages of each of their settings. This concerns both kayak and rowing, and, moreover, the same problem can be encountered in the human body itself, where small postural displacements can make a great difference both from the point of view of impulsive behaviour, and the regulation of stiffness and time required to fix certain joints.

# 0.7 – The Three Radii

Adjusting the levers on which to apply force represents a serious challenge in both rowing and kayak. The optimisation of levers in rowing can be very time-consuming, whereas in kayak one can, theoretically, 'give it a shot' with each stroke and, unfortunately, this can happen during the execution of the stroke itself.


[Fig. 0.7]

We shall see in **Chapter 5** how three simple levers in kayak represent a way to satisfy all situations, and that their relative variations cannot be selected at random, since for each erroneous combination one will experience a precise negative physical phenomenon.

The three radii are roughly shown in **fig. 0.7**. Please note that Radius 2 is an element that increases constantly from the moment of immersion to that of exit.

While setting up a rowing boat or kayak, one will primarily attempt to optimise the principal lever, seeing it as a transmission ratio the result of which is the optimisation of stroke frequency. Unfortunately, there are an infinite number of different settings that lead to the same stroke frequency, and only one of them results in maximum performance, and another in maximum efficiency.

Advancement per stroke depends mainly on:

1. The radius of curvature (Radius 1, 'R1' in **fig. 0.7**); and
2. The angular sector of the oar (or paddle) during traction (**Chapter 5**).

In order to optimise propulsive action, it is necessary to know what can happen with the overuse of Radius 1 or the sector. These two elements are the basis for optimising everything and at the same time avoiding negative physical phenomena.

The radius and the angular sector are not directly related to hydrodynamics: a skilled athlete can adapt to an erroneous setup without producing negative hydrodynamic effects. In such a case, we would move on to regulating the levers so as to have the correct ratio of transmission.

It is wrong, on the other hand, to try and regulate the ratio of transmission while ignoring the physical phenomena of hydrodynamics. For instance, it would be a waste of time to attempt to find the optimal ratio of transmission if, when in water, the oars or paddle should slide.

The next few chapters will not be concentrating on Radius 3. Radius 3 is, essentially, the height of the hand exercising traction relative to the centre of the submerged portion of the paddle. We can see this lever as the radius of rotation of the paddle relative to a fixed point in the water.

The choice of Radius 3 is a compromise the athlete makes to meet technical requirements together with the force load that his or her torso muscles can withstand. The smaller Radius 3, the more the hand exercising traction is low compared to the athlete's centre of mass: this in turn facilitates the muscles that have to work to stabilise the torso relative to the pelvis.

A fast submersion and a wide grip reduce Radius 3, which in turn can damage performance. However, imposing a high Radius 3 on an athlete can be counterproductive if they do not yet possess the strength to handle it.

## 0.8 - Harmony

**Chapter 8** deals with the most complex topics: harmony, ineffective acceleration and energy recovery. The overall motion is compared with the intended harmonic motion and the differences between the two are analysed:

1. Athlete delay: the athlete dispels energy inwards (in an introverted way), and, instead of pulling forward, winds up pushing backwards (intra-push);

2. Athlete ahead of time: the athlete is not reaching his or her highest efficiency level but is pulling forward during the active stage. The energy wasted does not disrupt the athlete since it is in the direction of the boat's motion (extra-pull); and
3. In the best-case scenario, the athlete is on the mark or only slightly ahead of time, harmoniously distributing the kinetic energy in elastic energy with maximum efficiency and effectiveness.

## 0.9 – Switching Off the Warning Light

When an athletes perform a movement that appears to be different from the usual technique used, it is probably because they are no longer able to compensate an error that can be hard to spot: we call this a 'warning light'. Trainers can respond in one of two ways:

1. The narrow-minded trainer – will focus solely on the unusual movement, trying to get rid of it. This is clearly wrong, as they are failing to realise that the warning light can work in our favour;
2. The open-minded trainer – will look for the true cause of the problem by exploiting the warning light itself. Once the real problem is solved, the warning light will go out. By learning the possible causes behind the particular error, we can easily find a solution.

Throughout this paper, we will mainly analyse first-rate athletes (selected from the A Finals of world cup races), but the evaluation methods used can also be applied to lesser skilled athletes.

However, we must take different measures depending on the athlete's level of skill:

1. Low-level athletes: before we can even think of being able to balance all the fundamental phenomena that occur on a boat, we must first build up the entire mechanisms of Micro-Technique in the gym. This paper is full of information on what happens when parameters are modified – for instance, what happens when we modify Radius 1 and Radius 2. Therefore, if we do not know the ideal settings for an athlete or crew, we must find these out by trial, by changing one parameter at a time, with a view to perfecting the core physical phenomena that athletes see or perceive.
2. High-level athletes: we must observe the athletes and film them right at the moment when they get into trouble; at that point the flaw (the warning light) will be easier to spot. In this case also, it will be useless to try getting rid of the warning light directly, as the root of the problem remains even when we are unable to see this warning light. At that stage, athletes still have the energy to compensate this phenomenon, and are motivated to do so in order to minimise damage and to retain the effectiveness of the action. We can see, therefore, that eliminating the root of the problem is not easy: trainers must find a way to fix the error by finding its cause and making it observable, and, in order to do so, athletes must stop compensating for this error. In this way we do the opposite of trying to 'switch off' the warning light. During technical training we can ask athletes to disregard movement effectiveness and compensation of error in order to work on efficiency.

When athletes make only one mistake, it would be incorrect to merely fix the visual appearance of the error. In cases where there are two mistakes, and one is dependent on the other, the situation is even worse – generally, the warning light we see will only show the second of the two, whereas our aim is to fix the first of the two errors in order to eradicate them both simultaneously.

In the most complex cases it is necessary to start over, and to do so we must make use of Meta-Technique. In this case, the athletes' or crew's level of skill does not allow for a quick fix, and the best advice is to start over from the cornerstone (**para. 0.3**) and to do so on small boats (K1 and K2 for kayak, and 1x or 2- for rowing).

One of the physical phenomena that affect Meta-Technique is directly linked to Micro-Technique, even outside water: the surge motion of the boat compared to the athlete. This element is so important that it deserves to be isolated and perfected at the gym – it can be achieved by using the adequate ergometers or inertial machines (**para. 0.4**). In this way, it will be possible to optimise the headway motion issues between athlete and boat without having to worry about any issues concerning water grip.

To tell the truth, we can actually achieve the same objective on a boat by doing as follows:

1. First, concentrating on the issues of Micro-technique to optimise boat motion while ignoring the behaviour of the paddle in water; and
2. Second, as soon as the first point is completed, water grip will be a much easier issue to solve as it can be construed in sync with the boat motion (**para. 0.5**).

We can further explain the point made at **para. 0.5**, regarding the interaction between water grip and boat motion, with a simple example: visualise a glass on a table and a person who has to pour water into that glass. If the table is on a boat that is out at sea and the sea is rough, the person must first establish balance so as to allow them to hold the bottle still with respect to the glass, and only at that point can they proceed to pour the water into the glass.

Unfortunately this phenomenon cannot be readily experienced by everybody as, in the case of low-level athletes, they will be stuck inside the kayak in a very uncomfortable way, and will only be able to move backwards (intra-push), and therefore any further movements that they could make would be unbalanced and could only serve to make the situation worse. Managing the boat motions effectively means, above all, to be in a comfortable position for each and every movement without losing balance (**para. 8.1**).

## 0.10 - Questionnaire

Trainers are more likely to achieve better results by using methods that they have mastered to perfection. We can only use other people's methods once we have completely understood them. We can, however, use the present material as a basis for discussion: the following questions can be a valuable incentive when discussing training with athletes or other trainers in a 'subtractive' manner.

That is, before we start innovating, to slowly begin to abandon methods that, despite having enabled the achievement of victory in the past, do not allow for further improvement. As argued by Jernej Župančič Regent in his trainer's manual (*04), if we wish to climb the highest mountain but end up on a hill, the best thing to do is to start over: in this case, 'subtractive' means coming down the hill, and locating the highest mountain peak before attempting the climb.

- A K1 W 200m completes the track in 40.0", passing the 100m line in 20.1" – is this a race with constant speed? (**Fig. 1.1**)
- In the last 250m of a 1000m race, a crew increases frequency to maintain speed: does this behaviour pertain to a high-, mid-, or low-level crew? (**Fig. 2.2**; **fig. 3.2**)
- Considering the three phases of paddling (start, centre and end), in which of these phases does the paddle have a higher angular speed? (**Fig. 7.2**)
- Do athletes maintain a certain fixed speed for the majority of the race? (**Chapters 1**, **2**, **3** and **4**)
- Do athletes maintain a certain 'mode' for the majority of the race? If so, is it quantifiable? What is it? (**Chapters 1**, **2**, **3** and **4**)
- When in a 1000m kayak race, or a 2000m rowing race, athletes increase speed for tactical reasons, how do they proceed to do so? Is it possible to define this 'mode' mathematically on the basis of speed and frequency? (**Chapters 2** and **5**)
- In a kayak K1, an athlete weighing 80kg moving at a speed of 5m/s is subjected to a brake force equal to 7kgf. In the aerial stage, does the athlete have to push the vessel forward with a force of 7kg? What happens if the athlete does not apply force on the vessel during the aerial stage? (**Fig. 7.1.5**)
- What are the effects of training with a hydrodynamic brake? (**Chapter 8**)
- Proceeding at constant speed, if athletes move at 80 strokes per minute ('spm') rather than at 100spm, do they need to apply more strength? (**Chapter 5**)
- An athlete who applies force on a boat with a higher speed utilises greater power. Is this positive or negative? (**Chapter 6.1**)
- In athletics, advancement per step (stride) is greater the faster the race: is this also the case in kayak? Why? (**Chapter 5.1**)
- If the boat is slowed down by water with a 7kgf, what amount of force must the athlete, on average, apply on the paddle? What does the average amount of force during the water stage depend on? Is the amount of force on the hands greater than 7kgf? (**Para. 5.1** and **Chapter 8**)
- Some kayakers are weak at the initial stage of the race, and stronger during the later stages, or vice versa. From the point of view of force application, what it the difference? (**Chapter 8**)
- Many athletes will hold the paddle underwater 65% of the time. What changes if they keep it submerged 55% or 75% of the time? (**Chapter 8**)

## 0.11 – Chapter Order

**Chapters 1-4** deal with the processing of GPS data taken from a number of international races. H-Graphs are used to define the parameter of energy per stroke, thus removing any uncertainty that may arise when parameters are not seen as a whole. The letter 'H' has been chosen to honour Heisenberg's Uncertainty Principle.

**Chapter 5** deals with those parameters measurable through the analysis of race video footage. We will conduct a quick analysis of the problems encountered in our reference athletes: these measures are known as Step 1 and Step 2.

**Chapter 6** concerns one of the most uncommon things one can see on the video footage: the transmission of power and the equilibrium of inertias. Two videos are used in which the dynamic phenomena are evident enough so as to be visible to the naked eye and numerically calculable. We will also see an example of how dynamic phenomena can be assessed by using inertial sensors. This is one of the few instances in which the 'invisible giant' (Meta-Technique) is carefully examined: this way, we can link the various events with the more apparent 'traces'. If, at a later point, we encounter the same traces – even if these should be less evident – we will, without a doubt, know the identity of the phenomenon that we are observing.

In **Chapter 7** I will be using the analyses known as Step 1 and Step 2 on the same athletes studied in the H-Graphs of Chapters 1-4.

**Chapter 8** deals with the most complex topics: harmony, ineffective acceleration, and the recovery of energy not used for propulsion.

In **Chapter 9** we will go back to the initial aim, and present a RoadMap to monitor its achievement. Finally, we will go through the principal training needed to understand and perfect the various elements.