SWIMMING FOR ALL
SWIMMING FOR LIFE

REFERENCE MANUAL FOR TEACHING AND TECHNICAL IMPROVEMENT IN SWIMMING

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1. INTRODUCTION

This book, as a reference manual of FINA for Teaching and Technical Improvement in Swimming, answers to the objectives previously defined in the strategic plan, namely:

- To qualitatively increase the number of persons who learn to swim, prioritizing swimming as the primer modality to practice, focusing primarily on children and youngsters.
- To guarantee conditions for the implementation of long-life programs of general swimming practice defined by FINA.
- To make learning to swim accessible all over the world, to encourage people to take part in swimming and to motivate and win them over to a lifelong active and healthy lifestyle.

It is not enough to have more people swimming, without ensuring that they do it with quality. Hence it is necessary to ensure, in addition to the availability of adequately registered infrastructures, the existence of diversified and technical competent programs for learning. Learning to swim, at any age, should be a personal enrichment experience and motivate towards a long-life practice of aquatic activities.

In this way, FINA seeks to intervene, support and promote the development of swimming at a national level, starting with the phases of swimming teaching with the most relevant contents: Adaptation to the aquatic environment, from early childhood (6 months-3 years) to second childhood onwards (3 years onwards); the structure of teaching levels in swimming schools; the technical learning and training in swimming; the technical models for teaching and develop the techniques of swimming, starts and turns.

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2.

ADAPTATION TO THE AQUATIC ENVIRONMENT

2.1 Early childhood (6 months - 3 years)

The aquatic environment is one of the richest and most diverse environments for the psychomotor stimulation of children. First and foremost, due to the different physical assumptions of moving in the aquatic environment or in land. The possibility of three-dimensional displacement, the combination of buoyancy and weight forces and propelling and drag forces, generate motor solutions substantially different from those taken on land. This particular argument, along with so many others, makes aquatic activities a mean of excellence of children's psychomotor development, from an early age.

It gradually became popularizing the beginning of aquatic activities before 36 months (i.e., adaptation to the aquatic environment). However, the beginning age of practice does not appear to be consensual. Nonetheless, several children start their aquatic practice a few months after birth and therefore early in their childhood. These programs of aquatic activities in early childhood are commonly known as "infant swimming".

The practice of aquatic activities in early childhood has developed from the mid-sixties to the present day. Initially, these programs had a strong focus on survival and self-rescue (Barbosa and Queirós, 2005). Nowadays, those programmes aim at the broad and multilateral development of the child in a psychomotor, cognitive and social perspective.

Given these facts, the water activities programmes in early childhood are facing increasingly to less rigid and formal teaching styles, with a greater preponderance of recreational component. In fact, this shift on teaching styles in which the student has a more active role, has become dominant in most contexts of teaching (Barbosa and Queirós, 2004; Barbosa et al., 2010; 2011; Langendorfer et al. al., 1988; Moreno, 2001; Moreno and Gutiérrez, 1998).

Nevertheless, compared to other aquatic activities of educational nature, those related to early childhood have an apparent gap in presenting entertaining and alternatives proposals for the learning sessions.

2.1.1 Contents and pedagogical progression of aquatic activities in early childhood

Regardless of the physical activity program in which the child is involved, its development in a harmonious and integral way should always be guaranteed. In this way, aquatic activities in early childhood include three main objectives (Barbosa and Queirós, 2005): (i) social; (ii) cognitive and; (iii) psychomotor.

From the social point of view, the sessions should aim to increase the time and quality of parents' interactions with their child, as well as to promote or extend the child's first social interactions. With this, we can support that the creation of formal opportunities for teaching aquatic competence offers the child a motor culture, alongside with cognitive and social development that together seems crucial factors in the perspective of the integral development of the child in society.

More recently the positive and significant effect of aquatic games (compared to the general population) on intellectual development has been demonstrated, particularly language development and simple mathematical notions (Jorgensen, 2012). Although the quality of teaching is determinant, despite the pedagogical design used, it is prevalent to resort to mathematical experiences in some tasks (e.g., to count motor actions or to relate shapes, colours, and textures to various psychomotor challenges). Accordingly, it is essential to match the game to the stage of cognitive development and the aquatic experience of the child. Water games involving complex rules and some abstraction ability should only be suggested to children in the stage of intuitive thought. In turn, aquatic games involving verbalization should be proposed only when language is minimally acquired by the child.

As for the psychomotor goals, today´s aquatic activities in early childhood focus on children´s multilateral motor development, being: (i) gross motor skills or; (ii) fine motor skills and related aspects. The aforementioned gross motor skills are described as: (i) flotations; (ii) displacements; (iii) immersions; (iv) passages and; (v) jumps; and the fine motor skills are described as: (i) manipulations; (ii) spatial orientation; (iii) rhythm; (iv) kinaesthetic differentiation and; (v) reaction.

From these contents approach, when implementing a pedagogical progression, some assumptions must arise. The effectiveness of teaching tasks and therefore the proposed program stems from the interaction between the characteristics of the student, the task and the involvement (Langendorfer and Bruya, 1995). More recently, the same author has evolved and deepened this concept. The complexity of the tasks is due to the combination between (Langendorfer, 2010): (i) the depth of the pool; (ii) the distance to swim (in the case of aquatic activities in early childhood it can be considered the distance of the displacement, immersion or passage); (ii) support (flotation or weight equipment); (iv) the assistance of third parties; (v) equipment (propulsion or drag equipment). Table 1 synthesizes the model proposed by Langendorfer (2010).

Table 1: Proposed developmental analysis of aquatic tasks (adapted from Langendorfer, 2010).

	Water Depth	**Distance of the displacement, immersion or passage**	**Support**	**Assistance**	**Equipment**
Easy (simple)	Shallow water (Immersed by the hip)	1 to 2 times body length	One or more flotation equipment	Assistance/Full support from a technician	Propulsion equipment
↓	Shallow water (Immersed by the chest)	2 to 5 times body length	Body flutter	Assistance/partial support of a technician	Without equipment
Difficult (complex)	Deep water	10 times body length	Weights added to body	Without assistance/support of a technician	Drag equipment

The pedagogical progression proposed here is fundamentally based on working upon gross motor skills, previously described by Barbosa and Queirós (2005). For this purpose, six steps are considered: (i) adaptation to the place; (ii) flotation; (iii) displacement; (iv) immersion; (v) passages and; (vi) jump. The adaptation to the place is the moment in which it is tried to promote the familiarization with the place along with the persons who participate in the sessions. Flotations and displacements are balancing skills. The flotation is no more than balance without displacement (vertical, ventral or dorsal). The displacements are balanced translations (vertical, ventral or dorsal) with traction by an adult on the water surface. The immersions (vertical and ventral) are displacements below the water surface. The passages are taken as a self-propelling action by the student at or below the water surface. Finally, jumps are actions of propulsion from land to the aquatic environment. The different proposed contents will be presented in isolated form for best understanding. However, throughout the classes, they should emerge in an interrelated and non-stagnant way. Consistently, each teacher sometimes presents some variations to this six steps sequence. In figure 1 the chronological order of the various contents is presented.

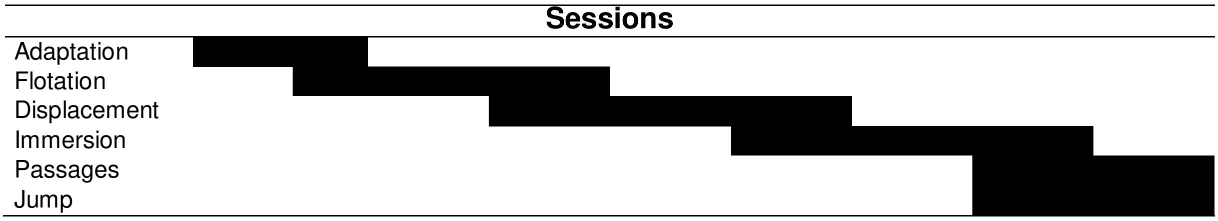

Figure 1: Chronological order of the various contents of an aquatic activities program in early childhood (adapted from Barbosa and Queirós, 2005).

Then again, alongside the gross motor skills approach, the development of fine motor skills should be promoted and encouraged. Manipulations are activities of control and handling of objects (handling, receiving, passing, throwing, etc.). In the case of manipulations, particular emphasis is placed on eye-hand coordination aimed at synchronizing segmental actions through visual control. The spatial orientation is notably distinct from that in land since it is two-dimensional (front-rear, left-right) whereas in aquatic environments it is three-dimensional (front-back, left-right, top-down). The work for the notion of rhythm is initially imposed by infantile songs and nursery rhymes, but that can later be extended to the rhythm of segmental execution of specific motor skills. The kinaesthetic differentiation is associated with the manipulation activities of different materials and objects with distinctive weights, textures, and dimensions which imposes motor control programs in the execution of the proposed skills. Finally, the reaction capacity that encourages the child to react as quickly as possible to a given stimulus (visual, auditory, tactile, etc.).

2.1.2 The teaching styles in aquatic activities in early childhood

It is usually considered that the teaching style adopted may influence the effectiveness of the teaching-learning process. The teaching style to be adopted should vary depending on the type of program being conducted and its objectives.

The aquatic activities in early childhood occur in sessions with a low-moderate number of children and with the presence of someone significant. The reduced number of participants in each session aims to create an eminently individualized teaching environment establishing a positive interaction between the student, the “significant” person and the teacher (Barbosa and Queirós, 2005). Thus, one of the most conducive teaching styles should be the "small group teaching" or even the "individualized instruction" under certain circumstances. However, a

strictly individualized style of teaching (i.e., single-student session), can prejudice the child's social promotion and development component.
In the teaching of aquatic activities, teachers traditionally adopt a strict teaching-learning method concerning its design, objectives, and development (Barbosa and Queirós, 2004). This practice is strongly oriented towards a "direct instruction" style. However, given the eminently individualized type of work performed in aquatic activities in early childhood, this style of teaching will not be the most favourable. This is a teaching-learning concept that implies the adoption by the teacher of a style of directive/assertive education, without the active participation of the learner, disconsidering his affective, social or cognitive dimensions (Langendorfer et al., 1988; Langendorfer and Bruya, 1995). These affective, social and cognitive dimensions are central elements in water activities programs in early childhood, which aims to be constructive, critical and reflexive. Thus, the choice should be based on teaching styles closer to the "guided discovery" and to "problem-solving" style in more advanced phases of the program, which became commonly known as recreational activities or educational games. In both teaching styles, the task is proposed without indicating the most effective solution, getting the student to seek for the best solution to achieve the proposed goal. In this way, the role of the teacher focuses on the student's orientation for the best solution (Barbosa and Queirós, 2004).
The aquatic game context seems to contain in itself many other advantages, the fact that (Barbosa and Queirós, 2004): (i) the student tends to lose his fears of the aquatic environment; (ii) is more motivating than analytical tasks; (iii) allows higher motor densities achieved per session; (iv) when properly applied, promote an increase in the effectiveness of the teaching-learning process.
The sequence of educational aquatic games should be ruled by the principle of gradual increase of complexity and number of variables to be controlled during the game: (i) the number of players; (ii) cooperation or opposition of the players; (iii) the materials to be used and; (iv) the characteristics of the environment. In the case of individual aquatic games, the approach is to introduce tasks involving a fixed point. Then, it is possible to promote the practice of games that are characterized by several variable points. Later on, the aquatic games will still have an individual characteristic where an interchanging action of colleagues is verified; then, the simultaneous action of all colleagues and; and finally, the introduction of opponents.

2.2 Second childhood on (3 years or more)

Among several physical exercise programs, aquatic activities are possibly the most prescribed for children and young people. This practice seems to have its peak between three and eleven or twelve years old. In this age group the aquatic activities program have a meaning: (i) utility - domain and comfort in the aquatic environment since it is not specific to the human being; (ii) health - given the physiological and biomechanical advantages that the aquatic environment presents for the practice of both healthy and so-called "unhealthy" children; (iii) educational - psychomotor, social and cognitive development of its practitioners and; (iv) safety - as a direct measure to reduce the risk of drowning.

Traditionally, an introductory program to aquatic activities entails a process of familiarization and adaptation to the aquatic environment. It is justified, therefore, because the most effective human behaviour in the aquatic environment is divergent from that which occurs in land regarding body position, breath control and propulsion (Barbosa and Queirós, 2005). This introductory program should be implemented to the middle-aged adult who starts his swimming practicing, to the elder before attending hydrogymnastics or water aerobics classes and to the child and youngsters before deciding between an educational, competitive or other water activity.

Introductory programs usually have strong adherence by students aged three to six or seven years of age. These programs appear not only as part of pre-school and basic education curricula in some countries, but also as a formative complement provided by city councils and private entities (i.e., colleges, gyms, and health clubs), or associations (i.e., sports clubs and other forms of associations).

For decades, the proposed teaching-learning models of adaptation to the aquatic environment were characterized by way more rigid and formal teaching styles (Catteau and Garoff, 1988) where the essence of the program was based in the skill that had to be performed. The analytic practice of skills was a constant, under a style of directive education assuming that each stimulus only has one correct answer. Nowadays, the teaching styles during aquatic readiness programs follow the trend of other aquatic activities (Barbosa et al., 2004; Gutiérrez, 1998) together with teaching paradigms based on the recreational and game components. The use of teaching styles like "guided discovery" and "problem-solving" is based on the proposal of a task with a particular objective where there can be multiple correct solutions. Therefore, given the age range of most aquatic adaptation programs, a less-restrictive teaching style should allow stronger creative freedom to the development of students' entire motor vocabulary. Another advantage of this style of teaching stems from the fact that these programs are the child's first contact with the aquatic environment, which can be frightening and embarrassing. The option for funny situations in the first stage of the program also serves, in a certain way, to create some empathy between the teacher and the student, as well as, to motivate the student to participate in the proposed tasks leaving the fear behind.

The Swiss Swimming teaching principles are the following:

- From the partial movement to the total movement: Learning through specific series of exercises leads the children from the simple movement structures to the more complicated or in a coordinate matter more demanding movements of the whole body.
- From the simpler to the more difficult: new movement sequences should be introduced in their simplest form and made more difficult as learning progresses.
- Principles for swimming lessons: Varied (different forms of exercises and variations should be used in the lessons to achieve the target form), playful (the children should be led to the target form in a playful way and with positive experiences) and age-appropriate (the children should be encouraged and challenged according to their age). Methodical and pedagogical aids such as metaphors and rituals support the teaching.
- Diving as a basic prerequisite for learning to swim: In order to learn to swim, it is essential that a child's head can be immersed in the water. That's why diving is so important in getting

used to water. Exhalation under water plays an important role right from the start. In addition, getting to know various swimming sports is fundamental. Water polo explaining the beginning of the game, artistic swimming focus on paddling as the central element for learning to swim, and diving promoting the head diving under water.
Less is more: Children should be confronted with a limited number of compulsory exercises. This contributes to an efficient and goal-focused practice of the target forms.

The Swiss Swimming Kids education is additionally based on the following methodical principles:
- Learning and performing through fun: A child who has fun and enjoyment in class is more productive and receptive. This means that a correspondingly greater learning success can be achieved. This means for swimming lessons that performance and results should be achieved through playful, varied and exciting instruction.
- Learning and practicing through versatile and variable repetition: In order to be able to memorize a correct technique, it is necessary to practice continuously and several times through the most versatile forms possible. Recognizable tasks and exercises are of great importance for children, as they are motivated by regular small successes. Nevertheless, the lessons must remain varied and exciting through variations in the exercise forms.
- Learning through active practice: A child should learn to swim in all lessons through active practice with as much movement time as possible. Waiting times at the edge of the pool should be avoided by designing efficient and movement-rich lessons. The presentation of a new form of movement or exercise should nevertheless always have room.

2.2.1 Adaptation to the aquatic environment and the concept of "aquatic readiness."

The acquisition of higher complexity motor skills implies that lower complexity motor skills should be consolidated. More simplistically, in land, only after the child has consolidated the gait that can move towards the acquisition of running technique, and then, for instance, hurdling. This phenomenon is justified by the fact that the process of interpersonal development takes place in a predictable sequence of qualitative change (Robertson, 1982, Seefeldt and Haubenstricker, 1982). On the other hand, this sequence of development is considered as universal and invariable, since every human being goes through the same phases and in the same order, as progression occurs according to each subject's specific developmental tempo (Gallahue, 1982).
Indeed, Gallahue (1982) proposed the most popularized interpersonal development model that is schematized in a pyramid. At the bottom of the pyramid is the first stage (reflex movements) typically characteristic of new-borns. At the next levels, two stages of essential movements arise (rudimentary movements such as crawling or walking; fundamental movements such as running, jumping or throwing). The top of the pyramid consists of sports movements. In this context, the basic motor skills (e.g., rudimentary and fundamental movements) are a prerequisite for the acquisition of more complex and more specific skills, such those of sports.

In effect, there is a moment of "readiness" in which the acquisition of sports skills will have a higher probability of success.
The transfer of this "readiness" assumption to the aquatic environment abilities led to the concept of "aquatic readiness." The adaptation to the aquatic environment is a teaching-learning process by which the student appropriates a set of basic aquatic motor skills, which are determinant for the latter approach of the specific aquatic motor skills (e.g., swimming techniques, starts, and turns).
Langendorfer and Bruya (1995), in a synthesis of previous works (Langendorfer et al., 1988) adapted the concepts of Gallahue (1982) for aquatic abilities. They have successfully proposed an adaptation of the inter-skills model carried out in the aquatic environment. This adaptation made such a furor that several other authors disseminated the concept (e.g., Moreno and Sanmartín, 1998; Barbosa and Queirós, 2004).
Figure 2 illustrates the adaptation of the Gallahue (1982) model by Langendorfer and Bruya (1995). In this model, the process traditionally labeled "adaptation to the aquatic environment" is at the stage of development of basic aquatic motor skills happening at the reflex skills stage and preceding the initial acquisition of specific aquatic motor skills. However, it is important to note that not always the student who starts to adapt to the aquatic environment participated in an organized, planned and systematized program to develop the reflex skills stage (also called aquatic activities in early childhood or "Infant swimming"). It may be speculated that naturally first participation in aquatic activities programs will facilitate and even enhance the acquisition of basic aquatic motor skills. However, this is the kind of opinion among swimming coaches based far more on common sense than in scientific evidence.

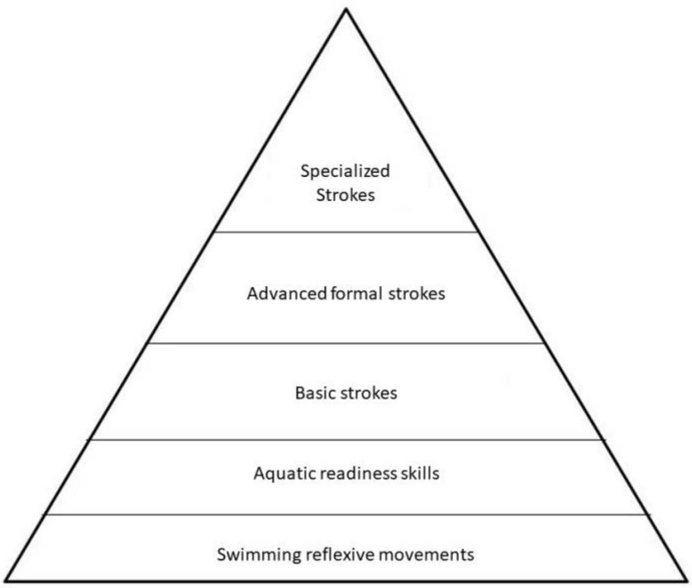

Figure 2: Adaptation of the Gallahue's motor skills development model (1982), according to Langendorfer and Bruya (1995).

Thus, the culmination of adaptation to the aquatic environment, ideally, matches with the moment when the student presents an "aquatic readiness" to acquire other types of motor skills. In this context, adaptation to the aquatic environment strives to (Barbosa and Queirós, 2004): (i) promote the student's familiarization with the aquatic environment; (ii) promote the creation of autonomy in the aquatic environment and; (iii) create the basis for later acquisition of specific aquatic motor skills.

2.2.2 Content and pedagogical progression of adaptation to the aquatic environment

For decades the concept that dominated was that of "components of adaptation to the aquatic environment." These components included "balance," "breathing" and "propulsion." This conception, possibly in an ambiguous way, was attributed to the French school that was immensely popular, at least in the other European countries. The work of Catteau and Garrof (1988) is the most representative of this paradigm, where the authors exhaustively dissect the three components and the mode they are taught. Interestingly, an earlier work addresses the so-called "trust method" of American origin (Ramos, 1936). This method considered from the baseline that for swimming it would be indispensable to: (i) float (i.e., balance); (ii) breath and; (iii) propel.

The balance has to do with the set of mechanical forces (buoyant force and weight) that can affect the stability of the student either in the vertical position, or in the horizontal (ventral and dorsal), or the variation from ventral to dorsal horizontal positions (rotations). Breathing reports to the mechanical and physiological mechanisms that underlie the act of inhalation and exhalation (mouth and nose). The propulsion reports to the game between two other mechanical forces (propulsive and drag forces) and to what extent the sum of these imposes the translation of the body.

Between the late 1980s and the mid-1990s, aquatic activities with children and young people are no longer essentially utilitarian and/or survivalist and have a robust educational characteristic. It is in this context of the harmonious education and development of the child as a whole in its various aspects that, in addition to gross motor skills (i.e., balance, breathing, and propulsion), the development of fine motor skills becomes contemplated in the same way (i.e., manipulations). Indeed, currently, manipulative skills are part of the paradigms of adaptation to the aquatic environment of authors as distinct as, for example, the Americans (Langendorfer and Bruya, 1995), the Spanish (Moreno and Sanmartín, 1998) or the Portuguese (Barbosa and Queirós, 2004, 2005). Indeed, the objective of manipulations is to maintain interaction between the student and one or more objects, allowing its exploration and possibilities (Moreno and Sanmartín, 1998). This kind of interactions has been often explored in land and can also be viewed from a sports perspective. Moreover, manipulations can be determinant for the readiness in specific aquatic motor skills of certain collective sports games played in the aquatic environment (e.g., Aquaball, Water Polo or Underwater Hockey). Figure 3 schematizes the basic aquatic motor skills and their sub-abilities.

Balance	Breathing
Vertical Ventral (flotation) Dorsal (flotation) Rotations	Inhales/exhales Mouth/nose
Propulsion	**Manipulations**
Leg Propulsion Arms propulsion synchronization arms and legs Jumps	Handling Receiving Passing Throwing

Figure 3: Summary of basic aquatic motor skills and their sub-abilities.

In the past, Barbosa and Queirós (2004), after dissecting and discussing several models of pedagogical progression for adaptation to the aquatic environment, systematized them and presented their proposal. These authors defined three crucial stages to complete the adaptation to the aquatic environment successfully (Table 2). The first stage corresponds to the familiarization with the aquatic environment, which is a defining moment as the student can demonstrate some fear. Consequently, aims the acquisition of the first goal of adaptation to the aquatic environment (i.e., "to promote the familiarization of the student with the aquatic environment"). The second stage aims, essentially, to acquire the basic aquatic motor skills relevant to create autonomy and self-sufficiency in the aquatic environment. Therefore, the second goal of the process of adaptation to the aquatic environment (i.e., "to promote the creation of autonomy in the aquatic environment") is pursued. The third stage will serve as a transition between adaptation to the aquatic environment and subsequent steps in learning specific aquatic motor skills. That is, it aims the third goal of adaptation to the aquatic environment (i.e. "creating the basis for later learning specific aquatic motor skills").

Table 2: Proposal of pedagogical progression for adaptation to the aquatic environment (adapted from Barbosa and Queirós, 2004).

	1st Stage	2nd Stage	3rd Stage
Purpose of the Stage	Promote familiarization with the aquatic environment	Acquire autonomy in the aquatic environment	Create the basis for acquiring specific aquatic motor skills
Breathing	- Head immersion - Rhythmic exhalation	- Acquires respiratory rhythm	- Acquires respiratory control
balance	- Sustain the vertical position without supports	- Sustains the horizontal position (ventral and dorsal) - Performs immersions - Body rotation on the longitudinal axis	- Masters balance according to the segmental action and breathing - body rotation on the transversal axis

Propulsion	- Vertical displacement without supports	- Legs alternating actions - Legs actions associated with sustaining the horizontal position - Jump feet first	- Arms and legs alternating actions - Arms and legs actions associated with breathing - Jump heads first
Manipulation	- Exploration and discovery of materials	- Combines throwing, receiving and handling objects with balance, breath, and propulsion - Selects the more suitable throwing, receiving and handlings for each situation	- Combines throwing, receiving and handling objects with balance, breath, and propulsion - Selects the more suitable throwing, receiving and handlings for each situation

It should also be noticed the existence of several intervening variables in the swimming teaching-learning process, most of them arising from the exceptionality of the context (water). We refer, mainly, to the context variables affecting the teacher's behaviour, teaching organization which of all can determine the effectiveness of learning to swim (Costa et al., 2012). Mostly, the literature seems to emphasize (e.g. Murray, 1980; Campaniço 1989; Langerdorfer, 2010; Costa et al., 2012) the following factors: (i) the number of students in the class, as the primary determinant factor of efficacy and overall process quality (preferably between 8 and 12 students); (ii) equipment and educational material available, while mechanism of complexity variability of stimulation and motivation); (iii) water temperature (which generally fluctuates between 29° and 31°); (iv) the regularity and attendance of classes (usually 2 classes per week between the ages of three and six); (v) pool depth, providing opportunities for the child to experience depth safely, namely for the consolidation of skills such as deep water displacement and immersion. An optimal combination of these factors will allow the construction of a more appealing, safe and conducive teaching environment for the acquisition of aquatic skills.

2.2.3 Teaching styles and adaptation to the aquatic environment

When teaching aquatic activities, traditionally, a rigid style is often adopted regarding the design, the objectives, and development of the class (Barbosa and Queirós, 2004). This practice is strongly oriented towards a "direct instruction" style. This style of command, centered on the teacher, is characterized by an exact definition of the tasks and skills that the student must perform. In other words, the teacher sets and plays a central role in the pre-interaction, during the interaction and post-interaction with the student (Sidentop, 1991). This style presents greater advantages when: (i) aims at the acquisition of skills in a short time; (ii) disciplinary control of the class is required; (iii) aims at the development of skills where there is only one correct solution.

However, the adaptation to the aquatic environment, aiming to familiarize, to acquire autonomy and to promote "aquatic readiness" for the recent acquisition of specific aquatic motor skills, is not compatible with unique and exclusive responses for a given situation (Moreno and Rodriguez, 1997).

This fact is of paramount importance as children usually attend classes of adaptation of aquatic environment where harmonious and multilateral development should not be neglected.

Alternatively, the adoption of teaching styles such as "guided discovery" and "problem-solving" may be an appropriate option. In these styles, there is no single correct answer to a given task. In the pre-interaction, the teacher must create an environmental problem, a game or a recreational activity with basic rules and objectives (Moreno, 2001). The role of the teacher, during the activity, is to guide the student towards one of several correct responses. In addition to all this, another advantage of these teaching styles - in the first stage of the teaching program can facilitate empathy between the teacher and the student. At the same time, it can motivate the student to participate in the proposed tasks and free himself from any fear he may have of the aquatic environment.

2.3 Structure the levels of teaching in swimming schools

The sports pedagogy literature has noted that optimal conditions for successful learning of sports gestures are dependent on a set of skills by the teacher, namely organization and hierarchy of learning situations (in the case of swimming, for different aquatic contexts and different aquatic experience of the students), diagnosis and proper didactic intervention. Most of these competencies can be considered of ordinal nature, resulting from the professional experience and academic background of each swimming teacher.

However, it is up to the swimming school to establish its pedagogical program (PP) which shall include aspects related to the organization of the school, the strategies, and methodologies of the teaching-learning process as well as the intended objectives. This PP is a guiding instrument of the teacher and fundamental in the swimming teaching-learning process. This guide should encompass the definition of the learning objectives of each level, the skills to be acquired by the students, the content to be addressed, the evaluation criteria and of other methodological and organizational aspects of the school (e.g., the different ways of approaching communication; or the preferred positions of the teacher for each level and age, namely their presence in the water) .

There are several authors who propose swimming teaching models based on progressive stages of learning. In essence, the most popular proposals go together with the literature on motor control and learning which has established the existence of at least three significant phases in learning: initial, or cognitive; intermediate, or associative; autonomous, or motor. We must therefore retain that the starting point of any PP corresponds to the total maladaptation of the subject to the aquatic environment and focuses on the promotion of a gradual acquisition of basic aquatic motor skills (hence, autonomy in the aquatic environment), towards technical proficiency (consequent learning of swimming techniques, starts and turns) suitable to the age and level of practice.

Any PP should consider general objectives in the following areas:

- Familiarization and knowledge of the aquatic environment, discovering and developing the potentials of each student, promoting well-being and satisfaction;
- Progressive and individualized proficiency in the aquatic environment according to balance, breath control, and immersion, propulsion, jump, and manipulations, as well

as other actions with the external environment, through basic aquatic skills enabling an autonomous and appropriate motor behaviour;

- Gradual proficiency of specific motor actions related to swimming in its various expressions;
- Complement along with the development of motor performance in competitive swimming (or, if applicable, to water polo, artistic swimming, open water or another) the individual development of physical and psychological capacities.

Considering the personal identity of the institution/club, while allowing some flexibility in the development of the curriculum with a wide range of choices in the definition of strategies and teaching methodologies, the following stages should be premises and landmarks for the definition of the activities to be developed in the PP:

- **Stage I - Fundamentals of Adaptation to the Aquatic Environment (AAE)**
  - Familiarization and first contact with the aquatic environment.
  - Balance (static and dynamic introductory)
  - Breathing (introductory and elementary)
  - Propulsion (introductory and elementary)
  - Jump/diving (introductory and elementary)
  - Manipulations (introductory)

- **Stage II - Basic Aquatic Skills (BAS)**
  - Dynamic balance (elementary and advanced)
  - Breathing (elementary and advanced)
  - Propulsion (elementary)
  - Jumps (elementary)
  - Manipulations (introductory and elementary)

- **Stage III - Specific Swimming Aquatic Skills (SAS)**
  - Crawl technique
  - Backstroke Technique
  - Breaststroke Technique
  - Butterfly technique
  - Starts, Turns, and Arrivals

The basic aquatic motor skills, or balance, breathing, propulsion, and jump, which are usually used and referenced in the swimming teaching-learning process, encompass several concepts and sub-areas or sub-skills. Some are more specific than others. In this way, these areas should never be understood in a narrow or a definite sense, but rather in a global perspective of constant interaction, where the various contents are interdependent.
In the following tables, we present for each stage (AAE, BAS, and SAS), the initial learning conditions, the general and specific objectives and some motor behaviours that must be specially developed.

Table 3: Stage I - Fundamentals of Adaptation to the Aquatic Environment (AAE)

TARGET POPULATION

- Individuals who do not know how to swim or with water phobia.

INITIAL CONDITION

- 1st contact with the aquatic environment without familiarization or with evident lack of comfort in the aquatic environment
- No glottal control or with apparent difficulty in respiratory control in the aquatic environment
- No autonomy in the static balance or with apparent difficulty

General objectives		Specific objectives/Competencies	Development/progression
Familiarization and first contact with the environment	Familiarization with the space surrounding the water plane	Knowledge of the behaviour rules and access to space. Knowledge of physical aspects (Dimensions, depths, etc.). Autonomy, safe entry into and safe exit out of water	Recognition, on the outside, of the water plan in generality and specificity Independent entry and exit
	Familiarization with the water plan	Global movements and segmental global	Walking and all kinds of displacements with various supports in various directions
		Simple immersion at low levels (below the airways)	Walking and all kinds of displacements with various supports in various directions at different depths
		Multiple displacements with support (standing) simple/complex	
Balance (static and dynamic introductory)	The notion of static/dynamic balance in the aquatic environment. Simple body rebalancing	Segmental and general flotation with and without support/assistance	Flotation Ventral, Dorsal, and somersault position with variations of the segmental positions.
	The notion of dynamic balance in aquatic environment and transitions between different body positions	Segmental and general flotation with and without support in a dynamic situation	Dynamic flotation in Ventral, Dorsal, and somersault position with variations of the segmental positions with assistance;
	Introduction to complex body rebalancing	Introduction to transitions between different body positions	Introduction to transitions between different body positions by his own
Breathing and orientation (introductory and elementary)	Adaptation and modification of the normal respiratory pattern aiming to progressive mechanization of the "new" standard to be used in the aquatic environment. Coping with orientation in and under the water	The notion of the glottal block (on the surface and in the aquatic environment)	Exercises performed above and at the surface level (immersion at the buccal level) in support and without displacements
		Expiration and inspiration with different tempos, rhythms, and amplitudes;	Exercises performed above and at the surface level (immersion at the buccal level) with and without support in displacements.
		Expiration and inspiration with different tempos, rhythms, and amplitudes combining with other tasks Eyes open under the water	Exercises performed in complete immersion (buccal and nasal level) in support and without displacements;
			Exercises performed in complete immersion (buccal and nasal level) with and without support in displacements.
			Exercises performed in complete immersion (buccal and nasal level) combining jumps

			and different body positions (ventral, dorsal, somersault, in transitions)
			Exercises to open the eyes under water
Propulsion (introductory and elementary)	Adaptation to the new propulsive pattern, recognizing the possibility of propulsive production of various body segments (mostly hands and feet)	Become aware of "new propulsive surfaces" and fundamental ways of using them for static balance in the aquatic environment. Sculling	Start with simple propulsion production tasks supporting balance in a vertical position (stationary and moving); Use of propulsive surfaces to "interfere/act" with exterior objects (floaters, dummies, etc.); Simple propulsion production tasks as assistance to static balance.
		Use of "new propulsive surfaces" and fundamental ways of using them for dynamic balance in aquatic environments in various situations and depths, combining them with balance situations.	Start with simple tasks of production of propulsion (feet and hands) in simple situations of dynamic balance and progressive increase of complexity: (i) Essentially equilibration until essentially propulsion; (ii) Palm and back of the foot to the back of the hand and sole. Varying from simple segmental actions (e.g., forearm-wrist-hand) to more complex ones (e.g., global body wave for propulsion in dolphin kicks).
Jump/diving (introductory and elementary)	Control of the abrupt transition from the terrestrial environment to the aquatic environment	Centred on a primary respiratory control, master the entry after the jump, commencing from the water level (gutter or stairs or other support) jumping in different ways and combining with other tasks	Simple front entrance (feet and then head) from sitting position, alternating knees, squatting, standing, with and without assistance. Same with flight variation and water entries.
		Performing jump entries, starting above water level (wall, block) by diving in various ways and combining with other tasks	Same as before, above water level, and progressively combining situations of balance and return to the surface, using basic propulsion and balance.
Manipulations (introductory)	Manipulation (grip and holding) of objects and materials in the aquatic environment, exploring them and using them as support.	The student makes a simple grip of various objects in an aquatic environment, transporting them, using them as support or throwing them, in situations of fixed support (swimming pool).	The student moves in the swimming pool in support, progressing to situations of greater instability and with different complexities of material, opposition or precision.
		Same as above but without solid supports.	Same as above but without solid supports.

Table 4: Stage 2 - Basic Aquatic Skills (BAS)

General objectives		Specific objectives/Competencies	Development/progression
TARGET POPULATION			
▪ Individuals with Stage I of familiarization with the environment (AAE) completed. "They know how to swim" in its most elementary form.			
INITIAL CONDITION			
▪ Mastery of the practical situation of evaluation proposed on Stage I or similar. ▪ Individuals who wish to develop their basic aquatic skills and formal swimming techniques. ▪ No apparent dominance of dynamic balance and more complex propulsion situations. ▪ The introductory level of front crawl and backstroke.			
Dynamic balance (elementary and advanced)	Mastery of static balance	Segmental and global flotation dominated/acquired in the different situations and the different segmental positions.	Flotation in different body positions (Ventral, Dorsal, Lateral, Somersault) with variations of the segmental positions. Initially with the possibility of fixed assistance/supports (gutter, stairs) to semi-fixed assistance/supports (lane, colleague, and teacher) and then to non-fixed supports (several floaters). After mastery with support, perform without any support.
	Dynamic balance in general situations and closer to those specific to swimming techniques	Dynamic flotation and glides in different situations from the most general to the more formal and closer to swimming techniques. Dynamic flotation with transitions in the rotation in the transverse and longitudinal axis, from basic situations to elementary forms of swimming for decubitus transitions.	Dynamic flotation and various glides in different decubitus situations (ventral, dorsal and lateral), in different depths (surface, medium depth and deep), with variations of the segmental and global positions as well as the dynamic transition between them.
	Introduction to body position (dynamic balance) suitable for front crawl and backstroke	Rotation and dissociation of the scapular and pelvic girdles, in connection with the elemental actions of front crawl and backstroke.	Several combinations of exercises in dorsal and ventral position with the purpose of promoting rotation in the longitudinal axis in coordination with the actions of upper and lower limbs.
Breathing (elementary and advanced)	Consolidation and mastery of actions and respiratory pattern in all situations of the aquatic environment.	Glottal block. Global coordination of expiration and inspiration with different tempos, rhythms, and amplitudes, using the mouth and nose; Dominate the apnea in situations of comfort and low difficulty level	Use and development in conjunction with different tasks in the aquatic environment, and situations of increasing difficulty: (i) progressively more powerful and short-term inspirations; (ii) potent and short-term expirations as well as over a longer immersion time; (iii) Coordinated with introductory swimming actions (upper and lower limbs).
	breathing coordinated with various actions of upper and lower limbs	Coordination of breathing with the times of the elemental actions of lower limbs (2, 4 and six beats)	Frontal respiratory actions with various combinations of lower limbs propulsion. Respiratory lateral actions coordinated with body rotations and upper limbs actions.
Propulsion (elementary)	Improves and develops the various elementary elements of the new propulsive pattern, resorting to the	Use of propulsive surfaces and their elemental forms for the dynamic balance in the aquatic environment in different situations and depths, combining them with the various	Whenever possible in conjunction and combination with the dynamic balance, and with situations in which

	possibilities of producing a propulsive force of the different body segments.	situations and challenges proposed, from the situation of basic balance to more elaborate forms of swimming.	there is a demand for coordination and breath control.
	Introduction to Alternated Swimming Techniques	Introduction to the rudimentary propulsive actions of the front crawl and backstroke technique. Entry into the water and progressive notion of the positioning of propulsive surfaces. Principles of "high elbow" and underwater path.	Legs actions. Arms Actions Legs actions coordinated with arms actions. Same, coordinated with the breathing.
Jumps (elementary)	Developing the skills of jumping so dive safely with feet and head in various situations.	Making jumping entries, starting above water level (wall, starting block, or other higher platforms).	Jumps with a variation of the starting position (more or less flexion of the lower limbs, a variation of the supports (feet parallel together, separated feet, and alternated), the position of the upper limbs, head and trunk position. Jumps with a variation of flight trajectory (low, parabolic and vertical)
		Feet and head entries (depending on the objective) in the most suitable way (aligned, in resistance, etc.): (i) feet first from different heights guarantying low depth; (ii) Headfirst with aligned entry and horizontal glide to start swimming or other (ventral and dorsal).	Jumps with a variation of the position of entrance in the water (feet/head/other, extension/flexion, etc.) Several combinations of the above situations
Manipulations (introductory and elementary)	Elementary mastery of the environment through the handling and manipulation of several objects.	Throwing and receiving of various objects (balls, floaters, etc.): (i) Fixed support situation; (ii) In a situation of mobile support; (iii) No support (only water); (iv) Opposite. Transport (without support) in rudimentary swimming or other, of different elements (balls, floaters, colleagues)	Situations of fixed or mobile support, moving progressively to situations without external support. Variation of the object type (texture, shape, density) its manipulation (catch, throw, transport) and distance. With other difficulty variants (obstacles, precision, opposition, etc.)

Table 5: Stage 3 - Specific Swimming Aquatic Skills (SAS)

TARGET POPULATION
▪ Individuals with Stage II of BAS completed. Elementary mastery of the aquatic environment and that can swim front crawl and backstroke with introductory to elementary technique, and breaststroke and butterfly in non-introductory to introductory form.
INITIAL CONDITION
▪ Mastery of the practical situation of evaluation proposed in Step II or similar. ▪ Individuals who wish to develop their aquatic skills related to the most complex swimming techniques and mastery of the environment. ▪ No elementary or advanced mastery of more complex swimming propulsion techniques. ▪ Introductory to the elementary level of front crawl and backstroke and not introductory to introductory butterfly and breaststroke.

General objectives		Specific objectives/Competencies	Development/progression
Front crawl Technique	Swim in the front crawl technique, integrating all its associated technical elements, albeit in a primary way.	Introductory front crawl swim, with clear coordination of upper/lower limbs actions and breathing, associated with a good overall position in the water; Starts, Turns (flip turn) and arrival in accordance	In the literature, the teaching of alternated swimming techniques should be guided by an inherently sequential approach and mainly focused on the issues of: (i) The mastery of balance; (ii) The action of lower limbs; (iii) Respiratory cycle (several coordinations); (iv) The action of upper limbs (unilateral arm, bilateral arm, and coordination with lower limbs and with respiration. (v) Complete technique and coordination.
Backstroke Techniques	Swim in the backstroke technique, integrating all its associated technical elements, albeit in a primary way.	Introductory backstroke, with clear coordination of upper/lower limbs actions and breathing, associated with a good overall position in the water; Starts, Turns (flip turn) and arrival in accordance	In the literature, the teaching of alternated swimming techniques should be guided by an inherently sequential approach and mainly focused on the issues of: (i) The mastery of balance; (ii) The action of lower limbs; (iii) Respiratory cycle (several ways of coordination); (iv) The action of upper limbs (unilateral arm, bilateral arm, and coordination with lower limbs and with respiration. (v) Complete technique and coordination.
Breaststroke Techniques	Swim in the technique of breaststroke, integrating some of the leading technical elements associated, although in a primary way.	Introductory breaststroke, with elemental coordination of upper/lower limbs actions and breathing, associated with a good overall position in the water and gliding technique (stop in extension); Starts, Turns, and arrival in accordance Introduction to the underwater stroke of the breaststroke	In the literature, the teaching of simultaneous techniques should be guided by an inherently sequential approach and mainly focused on the issues of: (i) The mastery of balance; (ii) The action of lower limbs; (iii) The action of the upper limbs (Alternated, Simultaneous) (iv) Respiratory cycle (several ways of coordination); (v) Complete technique; (vi) Improvement.
Butterfly Techniques	Swim in the butterfly technique, integrating some of the leading technical elements associated, albeit in a very primary way.	Introductory butterfly swim, with elemental coordination of upper/lower limbs actions and breathing, associated with the undulation movement (Cephalocaudal); Starts, Turns, and arrival in accordance	In the literature, the teaching of simultaneous techniques should be guided by an inherently sequential approach and mainly focused on the issues of: (i) The mastery of balance; (ii) The action of lower limbs; (iii) The action of the upper limbs (Alternated, Simultaneous) (iv) Respiratory cycle (several ways of coordination); (v) Complete technique; (vi) Improvement.
Turns	The turns at maximum velocity in the different body axis (transverse, longitudinal and anteroposterior).	Execution of the turns in the different situations of swimming technique: (i) Front crawl and backstroke; (ii) Breaststroke and butterfly; (iii) Butterfly to backstroke; Backstroke	In dynamic balance with and without fixed or mobile assistance. Displacement at Surface and under the surface.

		to backstroke; (iv) Others associated with other forms of swimming.	With previous swimming with and without pushing off the wall, with and without gliding. With previous swimming with and without pushing off the wall, with and without gliding and restarting the swimming Combinations of several rotations in the various axis with different techniques and forms of swimming in the approach to the wall and exit.
Starts	Ventral and dorsal start, suitable for the following swimming action.	Start from the block defining the various possible base positions: (i) grab-start; (ii) track-start; (iii) Backstroke start with feet at different heights and levels	Performing dives varying starting position, aerial trajectory and entries. Combining starts with different situations and glides depth. Combining with glide, underwater actions and swim start.
Arrivals	To master the arrivals in the four swimming techniques	Arrivals to the wall with one hand, in alternated techniques, in the continuous arm action and without significant loss of speed. Arrivals to the wall with two hands, in simultaneous techniques, in the continuum of simultaneous action in a decisive way without significant loss of speed.	Ensure wall-to-wall arrivals at every workout regardless of the objectives. Ensure wall arrivals in all exercises of full stroke without loss of speed. Combine with speed changes and ensure mastery of the arrival of both arms in simultaneous techniques.

The sequence here suggested represents a succession of specific motor prerequisites for swimming. However, the application of this (or other similar) teaching systematization will always depend on the actual operating conditions of the swimming school. Nevertheless, it seems relevant to suggest (Table 6) some performance criteria that can be used as evaluation proposals between the stages.

Table 6: Motor and cognitive performance (criterion) for each learning stage.

Stage 1 (AAE)	**ATTITUDES AND COMPREHENSIONS EXPRESSED BY THE STUDENT**
	▪ It adopts a positive and receptive posture towards the aquatic environment, without fear or adverse reactions. ▪ It knows the essential characteristics of the aquatic environment and understands the possibilities and basic limitations of the behaviour in the aquatic environment. ▪ The growing feeling of autonomy in the aquatic environment, to "Know how to swim."
	PRACTICAL SITUATION OF FINAL EVALUATION
	(Reference distance from the water plane 10m to 20m) ▪ Entry the water feet first (from the block or wall), then comes to the surface, always oriented and with controlled breathing, rolls to the back position and moves with upper and lower limb propulsion (introductory backstroke) for about 5m. Arrive at the wall, goes up the gutter (if deck level pool). ▪ After diving again with head first, returns to the surface after gliding, always oriented, grabs on a board and in a ventral position propels himself with legs actions with breathing control in the front (about 10m) after which drops the board sustains (in static balance and/or by propulsion) without displacement, for a period of about 10 ". ▪ In water, starting from the wall, after pushing off and glide performs 10m of the introductory front crawl.

Stage 2 (BAS)	**ATTITUDES AND COMPREHENSIONS EXPRESSED BY THE STUDENT**
	▪ Feeling of "Knowing how to swim" and progressive comfort in more complex situations. ▪ Knows the basic forms of propulsion and progressively understands the different ways of producing it and its applications. ▪ Knows and dominates the respiratory actions and their effects progressively. ▪ Knows the fundamentals of front crawl and backstroke technique
	PRACTICAL SITUATION OF FINAL EVALUATION
	▪ Starting from the block, dives head first and glides lined up in the Basic Hydrodynamic Position (BHP) comes to the surface and starts front crawl (elemental) for about 15m, dives and goes to the bottom catching an object (referral ≥ 1.40m depth) comes back to the surface and transports it in the dorsal position on the chest or forehead, executing propulsion by basic sculling (direction of the head) to the wall. ▪ Starting from the back position (introductory backstroke start) from the block or wall, short underwater glide (nasal breathing control) comes to the surface and starts backstroke (elemental) for about 10m, rotates to the ventral position and executes a somersault and then catches a ball and carries it at the surface in a water polo or alternating front crawl arm actions and simultaneous legs actions (breaststroke legs actions) to the wall (about 5m). If in a deck level pool, gets off with the short simultaneous action of legs (butterfly kick). ▪ Start from the block, glides and performs underwater dolphin kick to the surface, continuous butterfly kick (5-10m) followed by basic gliding breaststroke (5-10m).
Stage 3 (SAS)	**ATTITUDES AND COMPREHENSIONS EXPRESSED BY THE STUDENT**
	▪ Feeling of "Knowing how to swim" and progressive comfort in more complex situations. ▪ Knows the basic forms of propulsion and progressively understands the different ways of producing it and its practical applications in different contexts. ▪ Knows and dominates progressively respiratory actions and their effects. ▪ Knows the fundamentals of front crawl and backstroke techniques ▪ Knows the basics of breaststroke and butterfly techniques ▪ Wants to consolidate and be a regular swimming practitioner. ▪ Motivation to continue/follow for competitive swimming
	PRACTICAL SITUATION OF FINAL EVALUATION
	▪ Regulatory ventral start from the block at the starting voice (Defines starting position, parabolic flight phase and entry with head first ("clean") followed by streamlined glide (BHP) comes to the surface with appropriate underwater actions and starts swimming front crawl (elementary) for about 15m, dives and goes to the bottom catching an object (referral ≥ 1.40m depth) comes back to the surface and transports it in the dorsal position on the chest or forehead, executing propulsion by basic sculling and lower limbs actions. ▪ Regulatory backstroke start, from the block at the starting voice, after entering the water, with the head in extension, glides and after underwater actions comes to the surface and starts swimming backstroke (elementary) for about 10m, rotates to the ventral position and executes a somersault and then catches a ball and carries it at the surface in a water polo or alternating front crawl arm actions and simultaneous legs actions (breaststroke legs actions) to the wall (about 5m) and throws the ball to a designated target. If in a deck level pool, gets off with the short simultaneous action of legs (butterfly kick). ▪ Start from the block, glides and performs underwater dolphin kick to the surface, continuous butterfly kick (5-10m) followed by basic gliding breaststroke (5-10m). ▪ 100m medley, or less, especially in butterfly and breaststroke, respective turns and start from the blocks.

2.4 Water Safety Education

Swimming forms an emergent and dynamic state of dependent behaviour, which does not rely on certain individual characteristics alone (Newell, 1986). Individual characteristics, motivation, and changing water conditions can drastically and rapidly change the “competence to swim” (Costa et al., 2018). Although the true cause of drowning is still an uncertain aspect, aquatic competence is a vital aspect for survival, especially in unknown and unstable aquatic contexts (e.g., Baker, O'Neil, Ginsburg, & Li, 1992). The aquatic abilities of the victims are generally inadequate or insufficient for survival (Garrido, Costa and Stallman, 2016), being unable to move towards a safe zone or to rotate and change body position, and may not be able to swim with curling (which becomes rapidly tiring, disabling the victim from swimming to safe areas or even stopping to rest) (Stallman et al., 2008).

Thus, water competence is a much more comprehensive and inclusive concept than 'swimming skill', since it also includes both cognitive and afferent competencies (Moran et al., 2012; Stallman et al., in Press), making it especially relevant in the prevention of drowning (Garrido, Costa and Stallman, 2016). The next table lists the latest framework for water competences identified as essential (supported by research evidence) for reducing the risk of drowning (Stallman, Moran, Langerdorfer, and Quan, 2017), which also includes water safety attitudes, values and also the understanding of differences in water competence complexity between controlled and variable aquatic contexts. The importance of preventing drowning in swimming education is therefore justified, thus facilitating the ability to adapt to unpredictable situations in water.

Table 7. Water competencies and drowning prevention (Stallman et al., 2017).

WATER COMPETENCIES			
1	Safe entry Entry into water Surface and level off	9	Clothed water competencies
2	Breath control Integrated and effective breathing	10	Open water competencies
3	Stationary surface competencies Float front and back Tread water	11	Knowledge of local hazards
4	Water orientation competencies Roll from front to back, back to front Turn, L and R, on front and Back	12	Coping with risk Recognize and avoid risk Assessment of risk and action
5	Swimming competencies Swim on the front Swim on the back	13	Assess personal competency
6	Underwater competencies Surface dive Swim underwater	14	Recognize/assist a drowning person
7	Safe exit	15	Water safety attitudes and values
8	Use of personal flotation devices (PFDs)		

SWIMMING FOR ALL
SWIMMING FOR LIFE

3. LEARNING AND TECHNICAL TRAINING IN AQUATIC ACTIVITIES

3.1 The scientific competence of the swimming teacher

Scientific competence is, generally, defined as the ability to implement the scientific method in research. This ability involves consulting relevant and up-to-date literature, as well as conducting research or fieldwork. There must be a posteriori ability to interpret the information obtained and if appropriate to apply it in the context of intervention.

According to the new paradigms of teaching, scientific competence serves to: (i) know how to apply knowledge and develop the capacity to understand and solve problems in new and unfamiliar situations, in broad and multidisciplinary contexts; (ii) be able to integrate knowledge, deal with complex issues, develop solutions or make judgments in situations of limited or incomplete information, including reflections on the applications and ethical and social responsibilities that result from such solutions and judgments; (iii) be able to communicate findings, the reasoning underlying them, in a clear and unambiguous way.

Applying these principles for swimming, the success of the teaching-learning process also comes from the culture and scientific competence of the teacher. In parallel with other professional areas, the performance of the swimming teacher should be based more on the scientific evidence and less on common sense. Here, scientific competence encompasses the mastery of the technical model of motor skills to be taught. Necessarily the teacher should master the biophysical assumptions (kinematic, hydrodynamic, hydrostatic, physiological, etc.) inherent to each of the motor skills according to scientific paradigms of the moment.

When immersed in a fluid a body (in this case, the student) will be subject to four broad groups of external forces: (i) weight; (ii) buoyant force; (iii) drag; (iv) propulsion. It is the game between the pair: (i) weight-buoyant force that establishes the balance; (ii) drag-propulsion which defines the swimming velocity. The observation of the technique focuses exhaustively on the factors that may affect each of the forces and the relationship that is established between them.

However, the student's biomechanical behaviour has direct repercussions on his physiological response. Several combinations between drag and propulsion can obtain the same swimming velocity. However, there will be one with the lowest energy cost and, therefore, more efficient for the same output. The better efficiency will be obtained with a lower drag and higher propulsive forces. Figure 3 presents a deterministic model of the relationship between drag propulsive forces. From the model, it is easy to verify that the conjugation of different intensities of external forces may contribute to equal increments of swimming velocity.

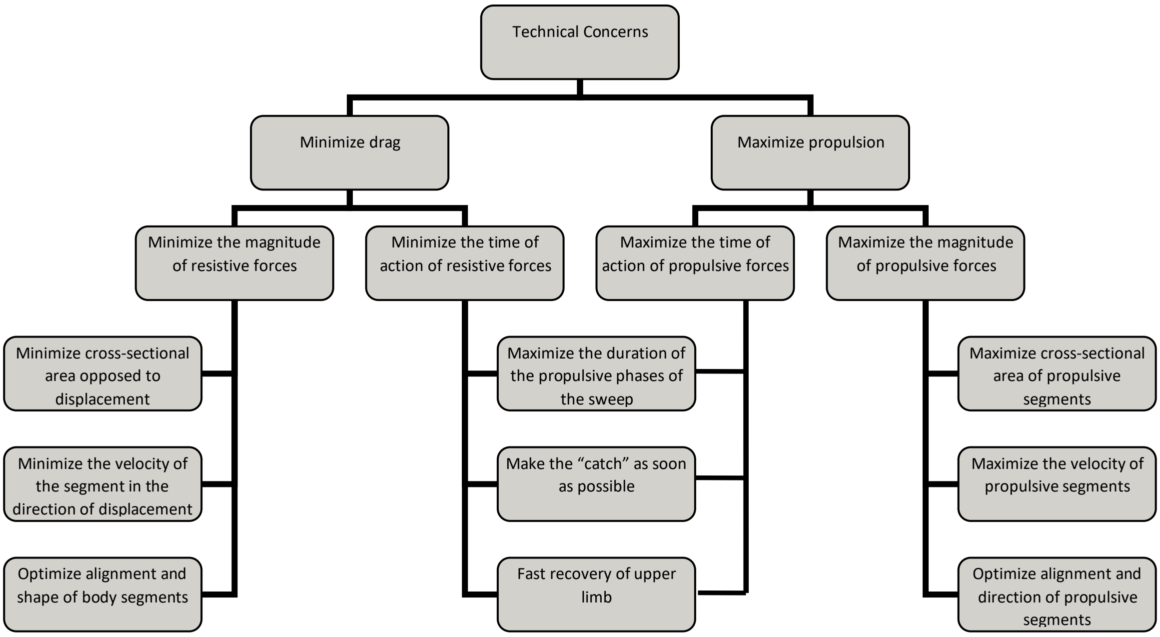

Figure 4: Deterministic model putting side by side drag and propulsive forces (adapted from Sanders, 2002a).

The technical model is a reflexive exercise of defining the essential assumptions or critical elements for better efficiency and performance. The scientific competence of the teacher is based on the need for a systematic analysis of the biophysical responses of each student during an aquatic activities program.

3.2 The technique

The learning and the technical training constitute a fundamental step in the long-term training of the swimmer, whether in an educational, competitive or health perspective. Teaching and perfecting swimming techniques, starts and turns are pedagogical acts that should always be oriented towards the preparation of the specific competencies' framework of the future swimmer (Conceição et al., 2011). This is a process that involves phenomena around Biomechanics, Motor Control and Learning, Motor Development, Psychology, Pedagogy, and Didactics.

As an illustration, consider a swimmer who, upon entering the water, keeps his head in cervical hyperextension (kinematics) rather than maintaining it in the alignment of the trunk and between the two upper limbs. The consequence will be an entry in the water with a significant increase of the wave drag (Hydrodynamics), and afterward, an immediate decrease of the swimming velocity (Kinematics). The cause for such error could be the fear of jumping or even the entrance in the water, reason why the elevation of the head could be a defense mechanism (Psychology).

This is typical behaviour in infants in the early childhood in adaptation to aquatic environment sessions (Motor Development). The solution must go through the whole pedagogical progression of the jumps to the water, avoiding immediate or speedy passages between phases (Pedagogy and Didactics). The swimmer must have enough time to appropriate the skill (Learning and Motor Control). Furthermore, each transition will only occur when the swimmer feels entirely comfortable at the actual stage of learning (Psychology). Finally, verbal feedbacks (e.g., say "in the first moment of the flight look forward and then chins into the chest") are also essential to prescribe appropriate behaviour to the swimmer (Pedagogy and Didactics).

3.3 Technique observation

The sports technique, like any human movement, can be analysed from a qualitative or quantitative point of view (Adrian and Cooper, 1995; Hall, 2005). Qualitative analysis is characterized by the systematic observation and qualitative evaluation of human movement to increase its efficiency (Knudson and Morrison, 1997). The quantitative analysis is based on the measurement of human movement, with the same objective but with a set of sophisticated techniques, either laboratory or field type. Several authors have described several models of qualitative analysis (Hay and Reid, 1982; Bartlett, 1997; Carr, 1997; Knudson and Morrison, 1997) as a possible alternative to quantitative analysis. These models aim to systematize the observations and attenuate as much as possible the subjectivity associated with this type of evaluation.

In addition to the qualitative analysis *versus* quantitative analysis dichotomy, other authors suggest different taxonomies. Pion et al. (1988) define three types of observations: free, direct and scientific. Free observation is not structured, can be applied in the field, and even though it is subjective, it is economical and fast. Direct observation is structured, can be applied in the field, it has a higher degree of objectivity than free observation, but still is economical and fast. The scientific observation is a structured analysis, used in experimental situations, and even though it is objective, it is also time-consuming and costly. In the educational context, direct observation should be privileged. Compared with free observation, direct observation presents a better systematization of the observation and produces more relevant results for the teaching-learning process. From the logistic point of view and the time available, it does not seem to be reasonable the systematic use of scientific observation. When in a competitive context, to promote the evaluation and training control, scientific observation makes perfect sense.

Knudson and Morrison (1997) characterize the analysis of sports technique as a continuum. At one end of this continuum lies qualitative observation. At the other end, the quantitative assessment. In the intermediate section semi-qualitative forms of observation emerge. Quantitative analysis is traditionally attributed to researchers in sports sciences, with an emphasis on biomechanics. The kinematic, dynamometric or electromyographic analyses of a sports technique are typically quantitative observations. In the intermediate exist semi-qualitative analysis processes that measure parameters that entail some subjectivity. For example, the analysis of the parameters of the stroke cycle (the stroke frequency and the distance per stroke). Qualitative procedures are performed, mostly, by teachers and coaches. These professionals tend to opt for qualitative analysis for two main reasons: (i) the simplicity of methodological procedures (Knudson and Morrison, 1997); (ii) involve less equipment, is cheaper and faster in pull off the results (Pease, 1999).

Qualitative analysis in swimming comes associated with the detection and analysis of the technical error (Campaniço and Silva, 1998). It is considered as technical errors (or technical faults) deviations from the most efficient model of performance for given motor skill (Reischle, 1993). In swimming, the technical error: (i) decreases the subject's propulsive capacity; (ii) increases drag forces; (iii) or a combination of these two factors. Since swimming velocity and efficiency are the result of the combination of propulsion versus drag, error analysis is a critical factor in the teaching-learning process.

Figure 4 presents the systematization of a qualitative analysis model proposed by Knudson and Morrison (1997). They suggest the following phases for a qualitative analysis model: i) Preparation - that consists of knowing the skill to observe (in its objective, its critical components and success criterion) and the performers; ii) Observation - this phase will define and implement an observational strategy. It is necessary to define the context in which observation takes place, the position, the most advantageous plan of observation and the number of observers; iii) Evaluation-Diagnosis - it is characterized by evaluating performance (identifying strengths or weaknesses) and determining intervention priorities; iv) Intervention - at this moment the most appropriate form of intervention is selected. Intervention can arise as feedback, as the use of a visual model, as the modification of the task, like manipulation, as task constraining, or tasks to exaggerate or overcompensate.

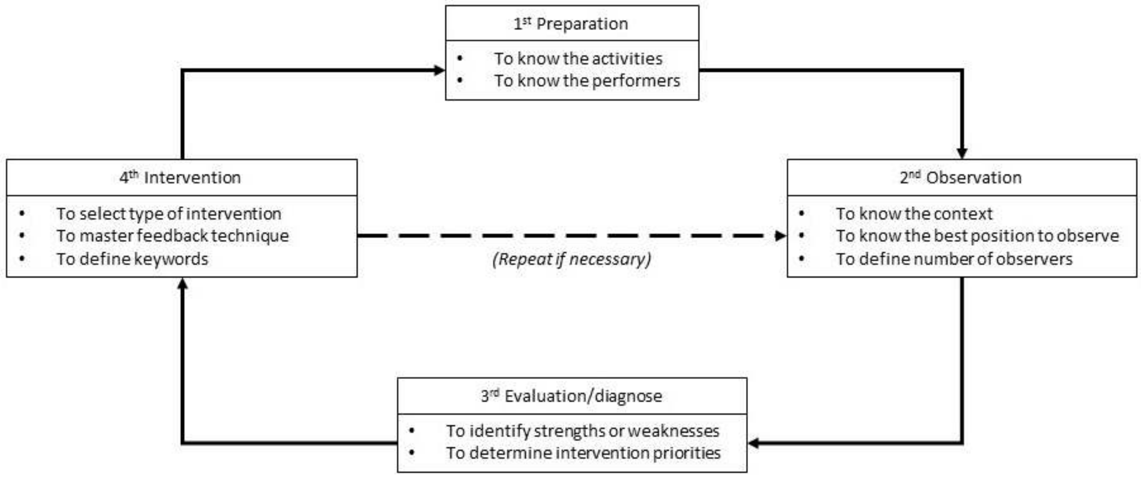

Figure 5: Synthesis of the qualitative analysis model proposed by Knudson and Morrison (1997).

The questions related to the preparation of the observation (i.e., knowing the activity) will be developed in the chapters referring to each of the swimming, starts and turns techniques.
As for the observation, the visual observation from the pool deck is not reliable at all. The turbulence, the distortion, and refraction of the immersed swimmer make the technique analysis particularly pernicious in this way (Pease, 1999). However, given the facility of application, and its reduced costs, it becomes one of the most used methodologies by swim teachers/coaches. Teachers with more experience in these procedures will be able to speculate on the occurrences of immersed kinematic chains (for example, the motor path of the upper limbs) from visualizing their consequences on emerged body portions (Pease, 1999).
The teacher must adopt a position according to the technique to be observed. One essential thing is to never stand with the back to the class. Another one is to move around the entire working space and try not to lose the whole of events in detriment of particular aspects. In some classes for babies and adaptation to the aquatic environment, the presence of the teacher in the water will promote greater proximity and familiarity with the students (Barbosa and Queirós, 2005). Generally speaking (because spatial orientation depends precisely on what the teacher is observing) , he/her should be oriented as follows (Barbosa and Queirós, 2005): i) the Crawl - on the same side student rolls over to breath, near the shoulder line or slightly behind; (ii) backstroke - slightly behind the hip, facing the direction of movement or at the opposite deck wall to which the student moves; iii) to Breaststroke and butterfly - facing the opposite direction of the displacement and approximately 1,5-2 meters ahead of the student or near the deck wall to which the student is heading; iv) in the ventral starts, flip turn and Backstroke to Breaststroke turn - on the side wall, facing the student and; v) in the backstroke start and open turns - on the deck wall, facing the student. In the case of an open turn, it may also assume a position similar to that described for the flip turn. The evaluation/diagnosis of errors and several interventions will be addressed later.

3.4 Identification of technical errors

Based on the analysis model of human movement presented previously, when observing it becomes clear the need to know the skill, its objectives, and the constraining factors; to identify and detect deviations to the most efficient model of execution; and finally, after identifying the errors, to define the best form of intervention, aiming its correction. In this context, observation, identification, and intervention regarding technical errors are critical factors for a higher quality of the teaching-learning process (Barbosa, 2005). Therefore, increasing the efficiency of technical execution will depend in no small extent on the teacher's ability to present a precise intervention of the observed performance. It is not enough for the teacher to master observation in a specific skill or to identify the technical error made by the student. The teacher must be able to identify what causes the errors and define the best strategy for their correction. The diagnosing and prescription competencies should be considered at the same level of importance.

However, scientific evidence suggests that, even with similar academic and professional experiences, different observers tend to obtain different results in the appreciation of some technical gestures in swimmers (Soares et al., 2001). Therefore, training in observation, in the identification of technical errors and exercise correction prescription should be a keystone in the formative background of a swimming teacher.

The tables 7 to 12 present, respectively, a systematization of the main errors observed in the four formal swimming techniques, starts and turns in an educational context, the possible causes, their biomechanical consequences, as well as possible forms of intervention.

To make it easier to understand, the technical errors are grouped according to the different phases of execution: the swimming (body position, lower limbs action, upper limbs action, upper limbs synchronization, upper and lower limbs synchronization, upper limbs and breathing synchronization), starts (starting position, push off the block, flight and entry into water, glide and start of swim) and turns (approach to the wall, turn, push off the wall, glide and restart of the swim). It was attempted that each possible cause corresponds to at least one correct suggestion to the respective technical error.

Table 8: Most common technical errors in the Front crawl, consequences, causes and forms of intervention (adapted from Barbosa, 2007).

	Most common errors	Consequences	Possible causes	Hypothetical intervention
Body position	Horizontal misalignment	Increase in cross-sectional area (A) - > increase in drag (D)	1) Deep kick of the lower limbs (LL) 2) Emerging head (try to hydroplane) 3) sunken hip	1) Listen to feet making noise and foam 2) Look at the pool bottom 3) Raise the hip
	Lateral misalignment	Increase in A - > increase in D	1) Absence longitudinal body rotation 2) Exclusive trunk rotation 3) Very sunken head 4) lateral recovery of upper limbs (UL) 5) UL passes the midline of the body during the in-sweep (iS)	1) and 2) point the shoulders alternately towards the ceiling; 3 beats to the left and 3 beats to the right 3) Look down and slightly forward 4) and 5) see intervention in the mistakes of the action of the UL
	Head position too low	Increase of A - > increase of D	1) Jaw leaning against the chest	1) Look down and slightly forward; contrast exercise (e.g., exercising flutter kick with head emerging and looking forward)
Action of the lower limb	Deep leg kick	Increase of A - > increase of D	1) sunken hip 2) Kick with high amplitude 3) Emerging head	1) Raise the hip 2) Listen to feet making noise and foam; short movement 3) Lower the head position; exercise without a foam board
	Leg kick with extended Knees	Decreases segmental acceleration - > decreases vorticity > decreases propulsion (Prop)	1) Reduced joint amplitude of the knee 2) Exclusive action of the thigh	1) and 2) "kicking" the water, bending the knee; manipulation; feedback
	"Bicycle" type kick	Increase A - > increase D Decrease A - > decrease propulsive drag (pD) and lift force (L)	1) Excessive action of the hip and knee	1) Keep LL more extended; Manipulation; feedback; exercise with fins (if possible)
	Foot in dorsiflexion	Decrease in A - > decreases Dp and L Sometimes resultant force (R) and effective propulsive force (P) with opposite directions in relation to displacement	1) Contraction of the anterior tibialis	1) Place the feet like ballerina; manipulation; feedback; exercise with fins (if possible)
	“Scissor” type kick	Decreases Prop. Decrease balancing action	1) Discontinuous ULxUL Synchronization 2) Exaggerated longitudinal rotation	1) Perform alternating synchronization; use pull-buoy to join LL 2) Exercising synchronization LL x breathing; exercising one-sided stroke, synchronized with leg kick and breathing (1UL x LL x breathing); use pull-buoy to join LL

Action of the upper limbs	Incorrect hand orientation at the entrance	Increase in D Trend for the down-sweep (dS) to go straight down	1) Hand does not rotate during recovery	1) Feedback; manipulation; exercise UL recovery
	Crossing body midline at the entrance or away from the shoulder line	Lateral misalignment Increase in D	1) Does not do the 2nd phase of UL recovery 2) Side recovery	1) Feedback; manipulation; touch with the fingertips on the board (1UL x LL x breathing) 2) Swim with the shoulder by the lanes, without touching
	Incomplete UL extension at the entrance	Changes the global synchronization Changes the amplitude of motor path (MP)	1) Look for increased velocity from the increase in the gestural frequency (GF)	1) Feedback ("making giant arm strokes"); manipulation; touch with the fingertips on the board (1UL x LL x breathing)
	Push the water directly down in the dS	Horizontal misalignment> increase of D	1) Does not make the three-dimensional curvilinear MP	1) Feedback (make an inverted "S"); manipulation; exercise 1UL x LL x breathing
	Fallen elbow on dS	Commit the following actions> Decrease Prop	1) Specific lack of UL strength 2) Lack of sensitivity to generate fixed points of propulsion	1) Feedback; manipulation; exercise 1UL x LL x breathing 2) Contrast exercises (e.g., UL with closed fist)
	Early start of iS	Decreases Prop	1) Does not accentuate the curvilinear MP 2) Reduced stroke amplitude	1) Feedback (hand passes under the body); manipulation; exercise 1UL x LL x breathing
	Amplitude of iS reduced	Lateral misalignment> decreases Prop .	1) Does not accentuate the curvilinear MP	1) Feedback; manipulation; exercise 1UL x LL x breathing
	Cross the midline of the body in the iS	Increased longitudinal rotation	1) Does not make the longitudinal rotation	1) Feedback; manipulation; exercise 1UL x LL x breathing
	MP rectilinear, without performing iS	Lateral misalignment - > Decreases Prop Loss of support in water> decreases L - > decreases Prop	1) Predominance pD in detriment of L	1) Feedback; manipulation; exercising the TM inverted "S"
	Do not culminate upsweep (uS) with extended UL	Decrease Prop	1) Lack of UL specific strength	1) Feedback (thumb comes out near the thigh; giant arm stroke); manipulation
	Push water straight up or back on uS	Decreases Prop Horizontal misalignment	1) Does not accentuate the curvilinear MP 2) Lack of UL specific strength	1) Feedback; manipulation; 2) Exercise 1UL x LL x breathing
	Recovers US laterally	Lateral misalignment	1) Lack of shoulder flexibility 2) Exit away from the thigh	1) and 2) Touching the armpit; Front crawl "surf"; Front crawl “zipper.”
	Recovers with Extended MS	Horizontal misalignment Increases recovery time Cross LL action	1) Excessive concern about entry and uS in extension	1) Touching the armpit; Front crawl "surf"; Front crawl “zipper.”
Synchronization upper x upper limbs	Overlapped synchronization	Discontinuous technique - > increased energy cost (EC)	1) UL entry after the end of the recovery of opposite UL	1) and 2) Feedback (when one hand enters, the other leaves, hands never meet); manipulation 2) Exercise technique without auxiliary materials

			2) Use of the foam board to exercise the complete technique	
	Semi-overlapped Synchronization	Discontinuous technique> EC increase	1) UL entry during the opposite UL iS	1) Feedback (when one hand comes in, the other comes out); manipulation
Synchronization upper x lower limbs	Makes 2 beats per cycle	Decrease Prop in every gestural cycle Possible horizontal misalignment	1) lack of LL specific strength	1) Feedback; exercise LL x breathing; to exercise LL with head emerging
	Makes 4 beats per cycle	Decrease Prop in every gestural cycle Horizontal misalignment	1) Stops the LL beat during the emersion of the head	1) Feedback (stronger LL beat during inspiration); exercise LL; exercise LL x breathing
Synchronization upper limbs x breathing	Raised head	Horizontal misalignment - > increase of D	1) the ear is not touching the shoulder 2) Exercised LL x lateral breathing with a two-hand grip on the plate 3) Does not rotate about the longitudinal axis	1) Feedback (look to the side and slightly behind); manipulation 2) Exercise LL x breathing with the arm on the side of the inspiration next to the body and the other on the extension 3) Exercise LL x longitudinal rotation of the body
	Early or late rotation	Decrease Prop Increases D Changes the overall synchronization of the technique	1) Start rotating the head during dS	1) Feedback (begins to turn the head after the shoulder bends); manipulation; exercise 1UL x LL x breathing
	Side rotation and looks forward	Horizontal misalignment - > increase of D	1) Does not inspire in the depression of the wave created by the head 2) Exercised LL x lateral breathing with a two-hand grip on the plate	1) Feedback; manipulation; exercise 1UL x breathing 2) Exercise LL x breathing with the arm on the side of the inspiration next to the body and the other on the extension
	Inhales and exhales during emersion	Horizontal misalignment - > increase of D	1) Does not dominate the respiratory rhythm of adaptation to the aquatic environment	1) Exercise breathing control (aquatic adaptation)

Table 9: Most common technical errors in backstroke, consequences, causes, and forms of intervention (adapted from Barbosa, 2007).

	Most common errors	Consequences	Possible causes	Hypothetical intervention
Body position	Horizontal misalignment	Increase of A - > increase of D	1) Deep LL beat 2) Look at feet 3) Sunken hip 4) High head	1) Listen to feet making noise and foam 2) Look at the ceiling 3) Raise the hip
	Lateral misalignment	Increase of A - > increase of D	1) Absence of longitudinal body rotation 2) Exclusive trunk rotation 3) UL lateral recovery	1) and 2) point the shoulders alternately towards the ceiling; 3 beats to the left and 3 beats to the right 3) see intervention in the mistakes of the action of the UL

Action of the lower limb	Deep leg kick	Increase of A - > increase of D	1) Sunken hip 2) Kick with high amplitude 3) Jaw leaning against the chest	1) Raise the hip 2) Listen to feet making noise and foam 3) Look at the ceiling
	Leg kick with extended Knees	Decreases segmental acceleration - > decreases vorticity - > decreases Prop	1) Reduced joint amplitude of the knee 2) Exclusive action of the thigh	1) and 2) manipulation; feedback ("kicking" the water, bending the knee); kick a ball to the surface
	"Bicycle" type kick	Increase of A - > increase of D decrease of A - > decrease pD and L	1) Excessive action of the hip and knee	1) Keep LL more extended; kinaesthetic feedback; feedback; exercise with fins (if possible)
	Foot in dorsiflexion	Decrease in A - > decreases pD and L Sometimes R and P with opposite directions in relation to displacement	1) Contraction of the anterior tibialis	1) kinaesthetic feedback; feedback (put the feet like a ballerina); exercise with fins (if possible)
Action of the upper limbs	Entry with the hand in pronation	Increase in D	1) Does not rotate hand during recovery 2) Rotates the body in the opposite direction to the entrance	1) Feedback (the first finger to enter the water is the little one); kinaesthetic feedback 2) Exercise LL x body rotation; feedback; kinaesthetic feedback
	Crossing body midline at entrance	Lateral misalignment	1) It recovers the UL bended	1) Feedback (keep the arm extended); kinaesthetic feedback; exercise simultaneous stroke
	Entry with UL away from the shoulder line	Increase in D Decrease MP amplitude	1) Recover the UL sideways	1) Feedback (arm near the ear); kinaesthetic feedback; swim very close to the lane separator without touching it
	Pushes the water directly down in the 1st down-sweep (1dS)	Horizontal misalignment	1) Does not accentuate the curvilinear MP 2) Do not rotate the wrist	1) and 2) Feedback (hand down, outside and back); kinaesthetic feedback; exercise 1UL x LL
	Fallen elbow on 1dS	Commits the following actions> Decreases Prop	1) Specific lack of UL strength	1) Feedback (sink the hand when pointing opposite shoulder/UL to the ceiling); kinaesthetic feedback; to exercise 1UL x LL
	Initiates the 1st upsweep (1uS) too soon	Decreases amplitude of MP - > decreases Prop	1) Does not associate longitudinal body rotation	1) Feedback; kinaesthetic feedback; to exercise LL x longitudinal rotation
	UL in extension during the 1uS	Decrease Prop	1) Does not accentuate the curvilinear MP	1) Feedback (sink the hand when pointing opposite shoulder/UL to the ceiling); kinaesthetic feedback; to exercise 1UL x LL
	Hand goes out of water in 1uS	Decrease Prop	1) Does not associate the longitudinal rotation of the body 2) Displacement of the hand vertical rather than diagonal (up/back)	1) Feedback; kinaesthetic feedback; to exercise LL x longitudinal rotation

	Poor hand orientation in 1uS	Decreases the Prop Horizontal Misalignment	1) Performs MP circular or rectilinear	1) Feedback; kinaesthetic feedback; to exercise 1UL x LL
	Push the water directly down or back on the 2nd down-sweep (2dS)	Horizontal misalignment (low) Changes the synchronization UL x UL Decreases Prop	1) Does not accentuate the curvilinear MP	1) Feedback; kinaesthetic feedback; to exercise 1UL x LL
	Recovers with UL bended	Crosses midline at arm entry	1) Exit very close to the trunk 2) Elbow is the first portion of the UL to come out of the water	1) Feedback (exit with extended arm); kinaesthetic feedback; to exercise 1UL x LL
	Recover the UL sideways	Lateral misalignment	1) Exit away from the thigh	1) Feedback (arm passes vertically at the shoulder line, arm functions as windmill); kinaesthetic feedback; to exercise 1UL x LL
	Does not rotates hand during recovery	Entry with the hand in pronation	1) Excessive concern with LL and/or body position	1) Feedback (exits with the palm turned inwards and enters with the palm facing outwards); kinaesthetic feedback; to exercise 1UL x LL
Synchronization upper x upper limbs	Overlapped Synchronization	Discontinuous technique - > EC increase	1) UL entrance after recovery of opposite UL 2) Use of foam board to exercise the complete technique	1) and 2) Feedback (when one hand enters, the other exits, hands never meet); kinaesthetic feedback 2) Exercise without auxiliary material
	Semi-overlapped Synchronization	Discontinuous technique - > EC increase	1) UL entrance during the 1uS of the opposite UL	1) Feedback (when one hand enters, the other exits); kinaesthetic feedback
Synchronization upper x lower limbs	Makes 2 beats per cycle	Decrease Prop in every gestural cycle Possible horizontal misalignment	1) Lack of specific LL strength 2) Does not master the rhythm of the kick	1) and 2) Feedback; exercise LL; exercise LL with one or two UL out of the water by pointing them to the ceiling
	Makes 4 beats per cycle	Decrease Prop in every gestural cycle Horizontal misalignment	1) Arrhythmic leg kicks	1) Feedback (keep the rhythm of the leg kick, legs never stop); exercise LL

Table 10: Most common technical errors in Breaststroke technique, consequences, causes and forms of intervention (adapted from Barbosa, 2007).

	Most common errors	Consequences	Possible causes	Hypothetical intervention
Body position	Slightly Inclined Body	Feet emerge at the end of recovery and Outsweep (oS) of LL	1) Head always immersed 2) Hip at Surface	1) Feedback (sinking feet slightly); Exercise LL synchronization x breathing 2) Feedback; Exercise MI with or without foam board and head emerged
	Excessively sunken body	Increase of A - > increase of D	1) Head always up 2) Does not dominate the horizontal balance	1) Feedback; Exercise LL synchronization x breathing

				2) Feedback; Exercising horizontal balance (adaptation to the aquatic environment)
Action of the lower limb	Recovery too fast	Increase of pD in the opposite displacement direction - > slows down Changes the overall synchronization of the technique Raises hip - > horizontal misalignment	1) Does not swims slow 2) Seek to increase the gestural frequency (GF)	1) and 2) Feedback (swim slowly, glide, accelerate the kick until joining the feet - iS - and recover slowly)
	Incomplete recovery	Decrease Prop in every gestural cycle	1) Does not glide 2) Concern about starting a new cycle fast	1) and 2) Feedback; Exercise LL, touching the heels with the hands, which are in the extension of the body (ventral or dorsal position)
	Accentuated movement of flexion and extension of the thigh	Increase of A - > increase of D Decrease Prop UL x LL Synchronization Change	1) Hip anteversion 2) Thigh flexion during recovery	1) and 2) Feedback (rotate the leg more than the thigh); to exercise LL in the dorsal position, without emerging knees
	oS and dS with feet in inversion	Decreases propulsive surface - > decreases pD and L - > decreases Prop Butterfly type kick *(technical rules do not allow)*	1) Sural triceps flexion 2) Motor transfer from butterfly LL	1) Feedback (feet facing outwards); kinaesthetic feedback; exercise push off from the wall with Breaststroke LL position; contrast exercises
	Pushes water straight back or out	Decrease Prop	1) Does not perform a circular motion	1) Feedback (make circular movement); kinaesthetic feedback; to exercise the LL (ventral and dorsal vertical position)
	Does not perform iS	Decreases MP amplitude and L - > decreases Prop	1) Do not join LL at the end of the recovery 2) Early start of the recovery	1) Feedback (joining the feet at the end of the leg movement; at the end of the movement, the soles of the feet are facing to each other); exercise LL; accentuate the length of the glide
	Foot comes out of the water at the end of recovery or beginning of oS	Decrease Prop	1) Shallow hip	1) Feedback (raise head slightly, cannot hear the characteristic noise of feet coming out and entering the water); to exercise the LL without foam board with or without emerged head
	Knees too much apart	Decreases L and vorticity - > decreases Prop	1) Accentuated hip and thigh movement 2) Lack of knee flexibility	1) and 2) Feedback (knees together); to exercise LL in vertical and dorsal position; pull-buoy to join knees
Action of the upper limbs	Pushing the water directly backward into oS	Decreases amplitude of MP - > decreases Prop	1) Does not accentuate the curvilinear movement 2) Falling elbow	1) and 2) Feedback (elbow higher than the hand); exercise 1UL x breathing; technical drill for the UL (e.g., breaststroke with front crawl leg kick)
	oS too short or too wide	Decreases the amplitude of the MP - > decreases the Prop	1) Does not accentuate the curvilinear movement 2) Falling elbow	1) and 2) Feedback (perform circular movement; elbow higher than the hand); exercise 1UL x breathing; technical drill for UL;

		Change UL x LL Synchronization - > Decreases Prop		contrast exercises (e.g., ask for short strokes for the error of presenting wide oS)
	Hands oriented inwards before passing the shoulder line	Decreases the amplitude of the MP - > decreases Prop	1) Very short oS	1) and 2) Feedback (only when the UL pass the shoulders is that the hand orient inwards, up and back); exercise 1UL x breathing; technical drill for UL
	Fallen elbow on oS	Commits the following actions - > Decreases Prop	1) Specific lack of UL strength	1) and 2) Feedback (high elbow); exercise 1UL x breathing; technical drill for UL; contrast exercises
	Hands stop close to the chest at the end of iS	Increases the discontinuity of the technique > increases EC	1) Create support to emerging the head	1) Feedback (as the hands approach the chest, perform the recovery, the hands stop only during the glide); exercise 1UL x breathing; technical drill for UL
	Does not join elbows at the end of iS	Decreases the amplitude of the iS - > decreases the Prop	1) Specific lack of UL strength 2) Do not accelerate at the end of iS 3) Privilege the pD instead of L	1) and 2) Feedback (approaching the elbows of the chest and not the hands); technical drill for UL (e.g., short arm stroke, quick joining elbows)
	Recover with hands spread away	Increases A - > increases D	1) Do not finish iS with elbows together 2) Does not dominates the hydrodynamic position	1) Feedback (one hand over the other during recovery and glide); contrast exercises 2) Exercise hydrodynamic position (adaptation to the aquatic environment); contrast exercises (e.g., glide in the hydrodynamic position with different positions of arms and hands)
	Recover with the angle of attack of the hand other than 0º	Applies pD in the opposite direction to the displacement Increase in D	1) Specific lack of UL strength 2) During the MP, the hand is not in the forearm extension 3) Does not dominates the hydrodynamic position	1) and 2) Feedback (one hand over the other in recovery); 3) Exercise hydrodynamic position (adaptation to the aquatic environment); contrast exercises
Synchronization upper x lower limbs	Exaggerated gliding	Increases discontinuity - > EC increase	1) Does not realize the loss of speed during the glide	1) Feedback (when feeling the slower speed, perform a new gestural cycle); slow the sliding period (approximately 3 seconds)
	Does not glide	Does not take advantage of the Prop of LL - > increase of GF	1) Early start of the new gestural cycle 2) Look for overlapping or continuous synchronization	1) and 2) Feedback (glide 3 seconds between the leg cycle and the arms cycle); accentuate glide for 3 seconds (“Breaststroke 1-2-3”)
	It overlaps the movements of UL and MI (spider position)	Prop of some segments annulled by D of opposite segments	1) Do not accentuate the glide 2) Looks for overlapping or continuous synchronization	1) and 2) Feedback (first make arm action, the leg action, and the glide; swim slowly); exercise the “Breaststroke 1-2-3”

Synchronization upper limbs x breathing	Does not raises the trunk	Does not take advantage of the inertia of the added mass of water in the body	1) Lack of propulsive support from UL and / or LL 1) Lack of trunk flexibility	1) and 2) Feedback (touching the earlobes with the shoulders when the head emerges) 2) Train trunk flexibility
	Uses respiratory rate 1: 2	*(technical rules do not allow)*	1) Tendency for the body to sink when the head emerges 2) The synchronization exercise 1UL x LL x breathing, breathing once every two or three strokes	1) Feedback (breathing all the stroke cycles); 2) Exercise LL x breathing and 1UL x breathing, breathing in all the gestural cycles
	Raises head during oS of the UL	Does not have support for emersion head - > sinks body> increases D	1) Early head exiting 2) Did not consolidate the content 1UL x LL x breathing	1) and 2) Feedback (raising the head during the iS of the UL); exercise 1UL x breathing; Technical drill for UL x breathing
	Raises head during UL recovery	Does not have support for emersion head - > sinks body> increases D	1) Delayed head emersion 2) Did not consolidate the content 1UL x LL x breathing	1) and 2) Feedback (elevate the head during the iS of the UL; during recovery, hide the head in the water to glide); exercise 1UL x breathing; Technical drill for UL x breathing

Table 11: Most common technical errors in butterfly technique, consequences, causes and forms of intervention (adapted from Barbosa, 2007).

	Most common errors	Consequences	Possible causes	Hypothetical intervention
Position and body movement	Insufficient undulation	Decreases energy transfer - > decreases vorticity> decreases Prop	1) Does not accentuate the vertical displacement of the shoulders and hip 2) Lack of trunk flexibility	1) Feedback (undulate like dolphins, and the hip comes out of the water while undulating); jump over the lane separator, or spaghetti, without touching them with the hip 2) Exercise the flexibility of the trunk
	Exaggerated undulation	Increasing vertical displacement - > decreases the horizontal displacement of the centre of mass	1) Exaggerates the vertical displacement of the shoulders and hip 2) Accentuated lumbar extension	1) and 2) Feedback (curl forward and up, forward and down); to exercise LL with foam board support
Action of the lower limb	Does not raise the hip during the descending beat (DB)	Decreases wave motion - > decreases the vertical displacement of LL - > decreases Prop	1) Insufficient undulation movement	1) Feedback (hip comes out of the water while undulating); exercising position and body movement
	Foot eversion and/or dorsiflexion	Decreases propulsive surface - > decreases pD and L - > decreases Prop	1) Lack of ankle flexibility 2) Contraction of the anterior tibialis	1) and 2) Feedback (tip-toes and inward-facing); kinaesthetic feedback; exercise LL; contrast exercises; exercise with fins (if possible)
	Excessive knee flexion	The exclusive action of the leg - > decreases the Prop Increased pressure drag	1) Does not undulates the body 2) No undulation of shoulders and hip	1) and 2) Feedback (undulate the whole body; undulation starts at the shoulders); exercise position and body movement

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	LL spread away	Decreases vorticity > decreases Prop	1) Does not assume the correct hydrodynamic position	1) Feedback (lower limbs closer together); join the LL with pull-buoy or elastic ring
	Alternating movement of LL	*(technical rules do not allow)*	1) Motor transfer of the LL action to the front crawl	1) Feedback (the dolphin kick is with both limbs at the same time); join LL with pull-buoy or elastic ring
Action of the upper limbs	Incorrect hand orientation at the entrance	Increase in D Trend for oS to be straight down (pronation)	1) Does not rotate the palm during UL recovery	1) Feedback (on entry, palm down and out); kinaesthetic feedback; exercise 1UL x LL x breathing and foam board, with the index finger being the first to touch the plate
	Entry with UL away from shoulder extension	Decreases amplitude of MP - > decreases Prop Increase in D	1) The 2nd phase of UL recovery does not ends 2) Recovery with immersed arm 3) Lack of shoulder flexibility	1) Feedback (front arm entry); kinaesthetic feedback; fingers to "scrape" foam board; to exercise 1UL x LL x breathing close to lane separator of the exercising arm and without touching it 2) and 3) Feedback (take the shoulders out of water in recovery); Exercising shoulder flexibility
	Push the water directly down at oS	Horizontal misalignment	1) Does not dominate the curvilinear MP (three-dimensional)	1) Feedback (hand down, outside and back); kinaesthetic feedback; exercise 1UL x LL x breathing
	Elbow fallen on oS	Commits the following actions - > Decreases Prop	1) Specific lack of UL strength 2) Entry of the elbow before the hand into the water	1) and 2) Feedback (high elbow); kinaesthetic feedback; exercise 1UL x LL x breathing; contrast exercises
	Early start of iS	Decreases amplitude of MP - > decreases Prop	1) Does not dominate the curvilinear MP 2) Concern to start UL recovery quickly	1) and 2) Feedback (hands move inwards after reaching the higher depth and passing under the shoulders); kinaesthetic feedback; 1UL x LL x breathing
	iS with very short or very wide MP	Changes the synchronization UL x LL Decreases L - > and Prop	1) Specific lack of UL strength 2) Does not dominate the curvilinear MP	1) and 2) Feedback (hands pass close to each other under the body); kinaesthetic feedback; exercise 1UL x LL x breathing; technical drill for UL x breath (e.g., front crawl flutter kick and butterfly arm stroke)
	Early start of uS	Decrease Prop of iS	1) iS with little amplitude 2) Specific lack of UL strength	1) and 2) Feedback (stretch arms back only after hands come near under the body); kinaesthetic feedback; exercise 1UL x LL x breathing; Technical drill for UL x breathing
	Push water straight up or back in uS	Decreases Prop Horizontal misalignment	1) Does not dominate the curvilinear MP	1) Feedback (hands up, outside and back); kinaesthetic feedback; exercise 1UL x LL x breathing; Technical drill for UL x breathing
	Does not end uS with UL extended	Decreases MP amplitude - > Decreases Prop	1) Specific lack of UL strength	1) Feedback (thumb "scrape" on the thigh); kinaesthetic feedback; Technical drill for UL x breathing; train specific strength

	Ends uS with UL away from LL	Decreases MP amplitude - > Decreases Prop	1) Specific lack of UL strength	1) Feedback (thumb "scrape" on the thigh); kinaesthetic feedback; Technical drill for UL x breathing; train specific strength
	Does not entirely rotates the palm during recovery	Entry with the hand in pronation	1) Recovery of UL too fast	1) Feedback (when passing the shoulders, rotate palms from the inside out); exercise 1UL x LL x breathing
Synchronization upper x lower limbs	Performs only one DB per stroke cycle	Decrease Prop by sign cycle It impairs airway and shoulder emersion	1) Specific lack of LL strength 2) Changed global synchronization	1) and 2) Feedback (one DB at the entrance and another at the exit of the hands); exercise LL and LL x breathing (one inspiration every two or four dolphin kicks); train specific strength
	Little strength of the second DB	Decrease Prop in every gestural cycle It impairs airway and shoulder emersion	1) Specific lack of LL strength 2) Changed global synchronization	1) Feedback (second DB as strong as the first); exercise LL and LL x breathing (one inspiration every two or four dolphin kicks); train specific strength
	First DB during oS or iS	Affects the undulation movement - > decreases Prop	1) Did not consolidate the content 1UL x LL x breathing	1) Feedback (first DB at hands entry); exercise 1UL x LL x breathing
	Sharp glide during UL entry	Increases technical discontinuity - > EC increase	1) Fatigue 2) Excessive use of exercise 1UL x LL x breathing with foam board	1) Feedback (do not stop hands ahead) 2) Whenever masters the exercise, do it without foam board or even the complete technique
Synchronization upper limbs x breathing	Late or early head emersion	Affects recovery of UL Affects UL entry and breathing (delayed) Affects uS (precocious) Affects the undulation movement	1) More than one ventilatory change per emersion 2) Did not consolidate the content 1UL x LL x breathing 3) Lack of cervical extension	1) Feedback (raises the head during uS); exercise control and breathing rhythm (adaptation to the aquatic environment) 2) and 3) Feedback (while inspiring, look forward); exercise 1UL x LL x breathing
	Emersion of head and trunk	Increase of A - > increase of D Affects the undulation movement	1) Emerges head straight up 2) Exaggerated undulation movement	1) Feedback (jaw touching water surface; neck stretching up and forward); Technical drill for UL x breathing (e.g., front crawl or breaststroke leg action with butterfly arms action) 2) Feedback (chest always in water, only remove the shoulders and arms from the water); exercising the position and movement of the body
	Does not elevates the shoulders	It impairs the airway emersion It hinders the recovery of UL	1) Second DB very weak 2) Lack of shoulder flexibility	1) Feedback (one beat at the entrance and one stronger at the exit of the hands); exercise LL and LL x breathing (one inspiration every two or four dolphin kicks) 2) Feedback (jaw to the chest in non-inspiratory cycles); strong second DB; exercising shoulder flexibility

Table 12: Most common technical errors of start techniques, consequences, causes and forms of intervention (adapted from Barbosa, 2008).

	Most common errors	Consequences	Possible causes	Hypothetical intervention
Initial position	Keep LL in full extension	Decreases push off intensity - > Decrease flight range	1) Fear of entering the water	1) Resume the progression of jumps in adaptation to the aquatic environment
	Do not bend the trunk ahead in the traditional start	Decreases push off intensity - > Decrease flight range	1) Fear of entering the water	1) Resume the progression of jumps in adaptation to the aquatic environment
	Incorrect hand placement	Decreases push off intensity - > Decrease flight range	1) Lack of flexibility 2) It only gives importance to the action of LL	1) Train specific flexibility 2) Emphasize the importance of "pushing" the block with the hands; Feedback ("first pull and then push the block with your hands")
	Feet are not shoulder-width apart	Decreases base area - > Decreases stability - > alters flight trajectory - > alters local entry into water	1) Fear of entering the water	1) Resume the progression of jumps in adaptation to the aquatic environment
	Hallux does not attach the anterior edge of the block	Decrease stability Feet slip during the push	1) Lack of awareness of security issues	1) Feedback ("big toes hold block lip")
	Do not emerge the hip in the backstroke start	Decrease flight arrow - > Decrease range> Increase wave D at entry	1) Lack of flexibility 2) Lack of foot push-off strength 3) Do not pull the block with UL	1) Train specific flexibility 2) Train explosive strength; Feedback ("Look back over and arches the body") 3) Train arm strength; Feedback ("pull the block with the arms")
Push off	Incomplete LL extension	Decreases push off intensity - > Decrease flight range	1) Fear of entering the water 2) Try to execute the K. Otto technique (i.e., flex and extend the LL during the flight)	1) Resume the progression of jumps in adaptation to the aquatic environment 2) Feedback (Keep LL extended during flight)
	LL powerless extension	Decreases push off intensity - > Decrease flight range	1) Fear of entering the water 2) Try to execute the K. Otto technique (i.e., flex and extend the LL during the flight)	1) Resume the progression of jumps in adaptation to the aquatic environment 2) Feedback (Keep LL extended during flight); train explosive strength
	Pushes higher upwards than forward	Decrease flight range	1) Try to decrease the D-wave by entering the body through a single hole created on the surface	1) Feedback ("jump forward"); entering the water in front of an object placed perpendicular to the track (e.g., spaghetti)
Flight and entry into the water	Entrance with LL flexed by the knees and/or thighs	Decrease flight range Increases D wave - > slows initial swimming speed	1) Fear of entering the water 2) Try to execute the K. Otto technique (i.e., flex and extend the LL during the flight) 3) Incomplete extension of LL during the push off	1) Resume the progression of jumps in adaptation to the aquatic environment 2) Feedback ("keeps the whole body extended during flight") 3) Train explosive strength

	Head in cervical hyperextension	Increases D-wave - > slows initial swimming speed	1) Fear of entering the water	1) Resume the progression of jumps in adaptation to the aquatic environment; ask to enter the water head first, inside an arch created with spaghetti; Feedback ("The first moment of the flight look forward, in the second moment, touch the chin to the chest")
	Several body segments that contact the surface of the water simultaneously	Increases D-wave - > slows initial swimming speed	1) Fear of entering the water	1) Resume the progression of jumps in adaptation to the aquatic environment; ask to enter the water head first, inside an arch created with a spaghetti
	Does not arch the back in the backstroke start	Increases D-wave - > slows initial swimming speed	1) Lack of flexibility 2) Lack of foot push 3) The basin does not emerge in the initial position	1) Train specific flexibility 2) Train explosive strength; Feedback ("Look back over and arch the body") 3) Feedback ("pull the block to you with your hands to the voice - on your marks")
	Drag the feet in the water during the flight in the backstroke start	Increases D-wave - > slows initial swimming speed	1) Lack of flexibility 2) Lack of foot push-off strength 3) The hip does not emerge in the initial position	1) Train specific flexibility 2) Train explosive strength; Feedback ("Look back over and arch the body") 3) Feedback ("pull the block to you with your hands to the voice - on your marks")
	Enter with the back in contact with the water in the backstroke start	Increases D-wave - > slows initial swimming speed	1) Lack of flexibility 2) Lack of foot push-off strength 3) The hip does not emerge in the initial position	1) Train specific flexibility 2) Train explosive strength; Feedback ("Look back over and arch the body") 3) Feedback ("pull the block to you with your hands to the voice - on your marks")
Glide and start of swimming	Very shallow or very deep	Increases the D-wave Increase time for swim start> decrease speed	1) Flying too flat (gliding at the surface) or more upwards than forwards (deep glide)	1) Feedback ("The first moment of the flight look forward, in the second moment, touch the chin to the chest," "as soon as you enter the water, orient the hands to the surface," "create a hole with the hands where passes the whole body ")
	Breathing in the first swim cycle	Increases D-wave - > slows initial swimming speed	1) Very long or deep immersion	1) Feedback ("do not breathe in the first stroke" - Front crawl and butterfly; "first arm stroke is underwater" - Breaststroke)
	Start the LL action when velocity is still high	Decreases swimming speed	1) Lack of sensitivity to displacement	1) Feedback ("you only start hitting legs when the speed of the glide decreases")
	The head is not aligned with the body	Increases friction D > Decreases swimming speed	1) Look forward to orienting yourself in the immersion space 2) Short flight time, not giving time to make the cervical flexion	1) Exercise glides in the hydrodynamic position; 2) Feedback ("The first moment of the flight look forward, in the second moment, touch the chin to the chest")

Table 7: Most common errors are the turning techniques, consequences, causes and forms of intervention (adapted from Barbosa, 2008).

	Most common errors	Consequences	Possible causes	Hypothetical intervention
Wall Approach	Reduce swimming speed	Increased turn time - > increased race ending time	1) Distance to start of the turn is not automated 2) Lack of orientation in space	1) and 2) Exercise the approach to the wall
	Look forward, at the flip turn	Increase of friction D - > decrease of swimming speed	1) Distance to start of the turn is not automated 2) Lack of orientation in space	1) and 2) Exercise the approach to the wall; Feedback ("do not breathe in the last stroke before the turn")
	Approaching the wall excessively, before turning from Backstroke to Backstroke, not having space to make the flip turn	Increased turn time - > increased race ending time Decreases push off the wall Increased distance traveled by the centre of mass	1) Distance to start of the turn is not automated 2) Orientation in space	1) and 2) Exercise the approach to the wall
	Do not correctly measure the distance from the wall to start the turn	Increased turn time - > increased race ending time Decreases push off the wall	1) Distance to start of the turn is not automated 2) Orientation in space 3) Does not dominate the somersault position	1) and 2) Exercise the approach to the wall 3) Exercise the somersault position
Turning	Grab the edge of the ending wall in the open turn	*(technical rules do not allow)*	1) Does not master the turn technique 2) Need to ventilate more than once with the emergent face	1 and 2) Feedback ("it is forbidden to grab the wall"; "barely touch the wall, you should throw it back over the water")
	Elevates excessively the body in the open turn	Increase in D	1) Need to ventilate more than once with the head emerged	1) Feedback ("inhale only once with your head out of water")
	Lose much time to inspire in the open turn	Increased turn time - > increased race ending time	1) Turns slowly 2) Need to ventilate more than once with the head emerged	1) Feedback ("inhale only once with your head out of water"; "breathe out with your head immersed before turning")
	Bad body position for flip turns (not somersault position)	Increased turn time - > increased race ending time	1) Not oriented in space 2) Does not dominate the somersault position	1) and 2) Exercise the grouped position, jellyfish position, and rotations (adaptation to the aquatic environment)
	Finish the flip turn early, extending the LL without contacting them with the wall	Increased turn time - > increased race ending time	1) Not oriented in space 2) Does not dominate the somersault position	1) and 2) Exercise the somersault position, jellyfish position, and rotations (adaptation to the aquatic environment)

	Do not perform aerial recovery of the UL that supports the wall in the open turn	Increased turn time - > increased race ending time Increase in D	1) Does not have a clear picture of the technical ability	1) Visual feedback (observation of a colleague performing the exercise correctly); verbal feedback ("the hand that touches the wall, goes out over the water and goes to the other hand")
Push off	The body is already in the ventral position before the push off	Increased turn time - > increased race ending time Alters the overall coordination of the technique	1) Rotate the body to a ventral position with feet still on the wall	1) Feedback ("push the wall in sideways position and glide till tummy faces down") 2) Exercise the hydrodynamic glide in the ventral and lateral position with wall pus off
	Push off too close to the surface	Increase D-wave	1) Decrease the duration of the push and glide to start swimming quickly 2) Need to ventilate in the first stroke cycle	1) Exercise the hydrodynamic glide in the ventral and lateral position with wall push off 2) Feedback ("do not breathe in the first stroke after the turn")
	Push off only with one foot	Decreases drive Changes the glide trajectory	1) Not oriented in space 2) Do not correctly measure the distance from the wall 3) Pushes off before rotating the torso (open turning)	1) and 2) Feedback ("you only push the wall when both feet are in contact with the wall and supported"); exercise the approach to the wall 3) Exercise the hydrodynamic glide in the ventral and lateral position with wall push off
	Body misalignment during push off	Increasing D - > decreases swimming speed	1) Incorrect drive 2) Does not dominate the hydrodynamic position	1) Exercise the approach to the wall and push off; Feedback ("you only push the wall when both feet are in contact with the wall and supported, and your hands are on top of each other") 2) Exercise the hydrodynamic glide in the ventral and lateral position with wall push off
Glide and transition to stroke	Breathing in the first stroke cycle	Increasing D - > decreases swimming speed	1) Reduced ability to maintain apnea 2) Glide too deep	1) Exercise the apnea; Feedback ("do not breathe in the first stroke after turning") 2) Exercise glide in hydrodynamic position; Feedback ("barely enter the water, move your hands to the surface")
	Do not perform underwater stroke at Breaststroke	decreases swimming speed	1) Reduced ability to maintain apnea	1) Exercise the apnea; Feedback ("in the first stroke you pull your hands beyond your hip and glide"); Exercise the gesture after pushing the wall; see who travels a greater distance with an arm stroke
	Do not perform dolphin kicks in the butterfly, Front crawl and Backstroke	decreases swimming speed	1) Reduced ability to maintain apnea 2) Do not dominate the technical gesture	1) Exercise the apnea; 2) Exercise the dolphin kick in depth; see who travels a greater distance in immersion; Exercise the dolphin kick in different positions (ventral, dorsal, lateral)
	Make a very long or too short glide	decreases swimming speed	1) Lack of sensitivity to displacement	1) Feedback ("you only start your leg beating when the speed of the glide decreases")

	Gliding with lateral misalignment body	Increasing D - > decreases swimming speed Increased distance traveled by the centre of mass	1) Incorrect drive 2) Does not dominate hydrodynamic position	1) Exercise the approach to the wall and push off; Feedback ("you only push the wall when both feet are in contact with the wall and supported, and your hands are on top of each other ") 2) Exercising the hydrodynamic glide in the ventral position (Front crawl, Breaststroke, and butterfly), dorsal (Backstroke) and lateral with a push-off from the wall

3.5 The technical drill

A technical drill is considered a motor task with the objective of increasing technical efficiency (Marinho, 2003). Approximately 90% of the energy spent while swimming is used for thermo-regulation purposes (Barbosa and Vilas-Boas, 2005). That is, of the swimmer's available energy this percentage is on average used to keep the body temperature stable. The remaining 10% is used for the production of external mechanical work (Barbosa and Villas-Boas, 2005), which main (but not only) purpose is to propel the swimmer. Therefore, the primary objective of teaching swimming techniques is to allow the subject to move in the aquatic environment at a given swimming speed (or mechanical work) with the least possible energy expenditure, i.e., to make the student more efficient. In this way it is considered possible to achieve higher swimming velocities at a given energy cost, making the swimmer more effective and improving his performance (Marinho et al., 2007).

The technical drill can be taxonomically categorized (Lucero, 2008): (i) analytical; (ii) contrast; (iii) exaggeration and; (iv) progressive. The analytical drill is characterized by the partial exercising of an isolated aspect of a segmental action. For example, exercise the lateral inspiration in the upright position, grasping the edge of the pool. In the case of contrast drill, the drill uses the exercise in at least two conditions (one more efficient and one less efficient), resulting in the identification of the best of the two outputs. For example, perform the flutter kick without the flutter kickboard with the head immersed and looking at the bottom of the pool and then with the head emerging and looking forward. When opting for a drill that evokes exaggeration, it is considered that the action is performed superlatively allowing the student to understand the desired technique. For example, ask for an exaggerated body roll to swim backstroke. Finally, the progressive drill is one that starts with a segmental action and/or more inter-segmental synchronization which will be carried out successively under more complex conditions. For example, performing a unilateral crawl stroke and then the whole technique.

The effectiveness of the proposed technical drill arises from the interaction between three elements (Langendorfer and Bruya, 1995): (i) the student; (ii) task and; (iii) involvement. Regarding the intrinsic characteristics of the student, the teacher should consider whether the drill to be proposed is appropriate for the age, anthropometric/morphological characteristics, the level of motor development and the experience. Regarding the task, the teacher should consider whether the specific purpose of the drill is appropriate to the session's general objective, and also consider its complexity and the possible existence of prerequisites for its execution. Regarding involvement, the teacher should consider the depth of the swimming pool, water temperature, existence and/or need for supporting materials, and the number of students per class.

Moreover, a set of complementary elements which also contribute to the effectiveness of the technical drill should be considered. It is not the single presentation of the task that ensures the quality of the teaching-learning process. These complementary elements are: (i) the precise definition of the drill's goal; (ii) ensuring an adequate potential learning time, with a satisfactory motor density, allowing to repeat the task; (iii) the constant reinforcement by the teacher and; (iv) to give as much feedback as possible.

4. ALTERNATE SWIMMING TECHNIQUE

In the field of teaching sports activities, competitive Swimming has been given greater attention to the understanding of its scientific and didactic-methodological assumptions. This fact may be due, on the one hand, to identification and understanding of sports performance determinants, or product's evolution, which is related to the teaching-learning process. On the other hand, it may be related to the peculiar characteristics of the activity, namely being a cyclical and closed sport in which the technique acquisition implies the regular exercise and repetition.

According to the macro-sequence of teaching to swim proposed the by Barbosa and Queirós (2005), after the adaptation to the aquatic environment of the subject, alternating swimming techniques (i.e., crawl and backstroke) are the first to be taught. The teaching of these swimming techniques constitutes a high percentage of teaching-learning tasks, both in education and training. Thus, the effectiveness of the teaching-learning process at this stage of the macro-sequence cannot be analysed without considering the preliminary phase of adaptation to the aquatic environment (Barbosa and Queirós, 2004). In other words, an adaptation to the aquatic environment perfectly consolidated, founded on the basic aquatic motor skills (i.e., balance, breathing, propulsion, and manipulations), as diversified as possible is an essential prerequisite.

At this stage, it is the teacher's responsibility to master the assumptions of the technical model and the teaching model of alternated swimming techniques. On the one hand, it is crucial to know and understand how to perform all the motor actions of crawl and backstroke (technical model) leading to an efficient swim. On the other hand, it is essential to have the notion of how these actions can be taught to the student/swimmer in a contents' perspective of increasing difficulty (teaching model) until the global gesture can be mastered.

4.1 Technical model of alternate techniques

The technical models that exist in swimming emerge from the propulsive models that consider the set of critical points that characterize the stroke technique. Theoretically, as the swimming speed increases the drag to overcome, which opposes the direction of movement, will also increase. In this way, it is required to the swimmer to possess a set of propulsive and non-propulsive trajectories that minimize drag and facilitate movement in the aquatic environment. In this context, the creation of technical models, which emerge from propulsive theories and that are reflected in the best swimmers in the world, has been used to optimize swimming teaching.

These models comprise a set of related inter-segmental actions whose trajectories allow to dissect all the phases of the swimming cycle. Knowing that propulsive mechanics in swimming are mainly dependent of the upper limbs, it is possible according to the trajectory of these segments to classify the main actions and the direct relationship with the other parts of the body.

Nevertheless, some attention should be given for other critical points such as body position, breathing and the action of the lower limbs. Although crawl technique and backstroke are similar in their symmetric and alternating execution, they differ slightly regarding propulsive and non-propulsive actions, so that the distinction should be made for a better teaching-learning process.

4.2 A teaching model for alternate techniques strokes

As far as education and training are concerned, it is generally seen that for much of the last century, the transmission and acquisition of knowledge or skills were privileged. The teaching was based on pre-defined objectives centred on knowledge, organized according to a linear and sequential logic. However, educational research has suggested that the subject plays a central role in the process. As such, now, it is recognized as indispensable to be able to operate in more complex contexts of knowledge construction. Hence that is spoken in teaching more directed to the development of skills.

Regarding education and training, it was found that during much of the last century the transmission and acquisition of knowledge or skills were privileged. The teaching was based on pre-defined objectives centered on knowledge, organized according to a linear and sequential logic. However, educational research has suggested that the subject plays a central role in the process. As such, it is fundamental to be able to operate in more complex contexts of knowledge construction, i.e., teaching aiming at the development of competences.

Within this context, it is important to point out that objectives and competencies are not synonymous. While objectives, considered as a product, can be achieved immediately in a work session, competencies take more extended periods of time to develop. This is a continuous process, which can contain different levels or degrees of development, aiming to improve results, and therefore, of the subjects' performance.

The development of competences is done through new and complex situations. This requires complex, non-routine and relevant problems to be solved (Santos, 2003), i.e., technical drills (teaching tasks). From this assumption arises the higher difficulty for teachers to manage in the class since open nature tasks are way more demanding than those in which teacher can have total control. Thus, it is up to the teacher, both in the class or training contexts, to propose complex tasks and challenges that stimulates the subjects.

It is considered in the literature (Maglischo, 2003; Barbosa and Queirós, 2005 ; Barbosa, 2007) that there are several elements characterizing the alternated technique, such as: (i) static and dynamic balance; (ii) the isolated action of each lower limb; (iii) the isolated action of each upper limb; (iv) the synchronization between the action of the two lower limbs; (v) the synchronization between the action of the two upper limbs; (vi) the respiratory cycle; (vii) the synchronization between the action of the lower limbs and the respiratory cycle; (viii) the synchronization between the action of the lower limbs and the upper limbs e; (ix) the synchronization between the action of the upper limbs and the respiratory cycle.

The proposed teaching model of the alternate techniques is based on an analytic-synthetic teaching method, also known as a mixed method (Barbosa and Queirós, 2005). In this method, there is a gradual increase in segmental actions (from the simplest to the most complex) until the global movement is reached. In this case, the appropriation of the whole technique is obtained from the continuous integration of new segmental actions and respective synchronization. After a brief analytical approach to a given segmental action, this will be quickly integrated into other segmental actions already consolidated. In this way, it is not only the exercise of the new segmental action but in the same way, the acquisition of the synchronization mechanisms between all the actions acquired in the meantime.
The micro-sequence of teaching that we propose is based on the principles previously mentioned. This micro-sequence is nothing more than the hierarchy of contents (read, the segmental actions) to present to the students. Thus, the sequence follows (adapted from Barbosa and Queirós, 2005): (i) static and dynamic balance; (ii) static and dynamic balance synchronized with the action of the lower limbs; (iii) static and dynamic balance synchronized with the action of the lower limbs and the respiratory cycle; (iv) static and dynamic balance synchronized with the action of the lower limbs and the unilateral respiratory and arm stroke; (v) static and dynamic balance synchronized with the action lower limbs, upper limbs and respiratory cycle (ie, complete technique); (vi) technical improvement, namely the upper limb segmental actions. For a better understanding, the teaching of alternated techniques begins with a particularly focused approach in the questions: (i) of balance; (ii) lower limb action; (iii) respiratory cycle; (iv) unilateral stroke; (v) whole technique; (vi) improvement. However, it is essential to emphasize the importance of the brief analytical exercise of each of these actions, which will soon be integrated into the segmental actions that have been previously acquired.

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5. SIMULTANEOUS SWIMMING TECHNIQUE

The teaching of simultaneous techniques, such as that of alternates, is based on the need for systematic practice and repetition. It turns out that, unlike other sports, the number of techniques to be practiced in competitive Swimming is scarce, so the execution of a rather finite number of technical gestures raises some limitations: (i) the overload on body structures; (ii) the monotony of sessions; (iii) the lower plasticity imposed on motor control. These limitations may be even more significant for the case of simultaneous techniques compared to alternated techniques.
According to the macro-sequence of teaching competitive swimming proposed by Barbosa and Queirós (2005), after the adaptation to the aquatic environment phase, the alternated swimming techniques (i.e., the front crawl and backstroke) are the first to be addressed; followed immediately by the simultaneous techniques (i.e., breaststroke and butterfly). The latter are the most complex to teach because of manifest coordinative difficulties (e.g., synchronization between upper and lower limbs) and/or kinanthropometric (i.e., strength and flexibility) of students. If these limitations are added to those referred previously for the so-called "classical" teaching tasks, there is an added complexity to the teaching of these two swimming techniques.
In this context, the technical drill emerges as a workable solution to complement the work developed using the more "classic" teaching tasks. That is, in order to reverse or mitigate the limitations described above is common to offer students different teaching tasks or "alternative" opposing the "classic" teaching tasks as.

5.1 Technical model of simultaneous techniques

We can refer, in the face of what has been presented throughout this book, that the efficiency of the sports gesture is one of the main responsible for the success or failure of the swimmer. The swimmer, in turn, is an individual being, with its own morphological and functional characteristics. This principle of biological individuality takes some authors to refer that a swimming stereotype may not be suitable to all swimmers. However, this does not mean the inexistence of a reference model, a hypothetical model that we consider to be very close to the actual swim model of high-level swimmers. It is also noted that in the breaststroke technique there are some variants of technical execution (for example, formal vs. natural), as described in detail in Louro et al. (2009).

5.2 Teaching model of simultaneous techniques

It is considered in the literature (eg, Maglischo, 2003; Barbosa and Queirós, 2005 ; Barbosa, 2007) that there are several characteristics of simultaneous techniques: (i) the static and dynamic balance; (ii) the isolated action of each lower limb; (iii) the isolated action of each upper limb; (iv) the synchronization between the action of the two lower limbs; (v) the synchronization between the action of the two upper limbs; (vi) the respiratory cycle; (vii) the synchronization between the action of the lower limbs and the respiratory cycle; (viii) the synchronization between the action lower limbs and upper limbs; (ix) the synchronization between the action of the upper limbs and the respiratory cycle.

Compared with the techniques of front crawl and backstroke, in the simultaneous techniques the synchronization between the two upper limbs, as well as between the two lower limbs, which is defined by the simultaneity of the actions, it is not of the same importance as in the alternated techniques.

The proposed teaching model of the simultaneous techniques, like the other swimming techniques, is based on an analytic-synthetic teaching method, also known as a mixed method (Barbosa and Queirós, 2005). In this method, there is a gradual increase in segmental actions (from the simplest to the most complex) until the global movement is reached (Barbosa et al., 2010).

In this way, the proposed teaching-learning micro-sequence follows the order (adapted from Barbosa and Queirós, 2005): (i) static and dynamic balance; (ii) static and dynamic balance synchronized with the action of the lower limbs; (iii) static and dynamic balance synchronized with the action of the lower limbs and the respiratory cycle; (iv) static and dynamic balance synchronized with the action of the lower limbs and the unilateral respiratory and arm stroke; (v) static and dynamic balance synchronized with the action of the lower limbs, upper limbs and respiratory cycle (i.e., complete technique); (vi) technical improvement, namely the upper limb segmental actions.

For a better understanding, the teaching of simultaneous techniques begins with a particularly focused approach in the questions: (i) of balance; (ii) lower limb action; (iii) respiratory cycle; (iv) unilateral stroke; (v) whole technique; (vi) improvement. However, it should be highlighted that the adopted teaching methodology should not include exclusively analytical teaching (i.e., isolated from each segment) integrating the actions into the global movement making it easier to be assimilated.

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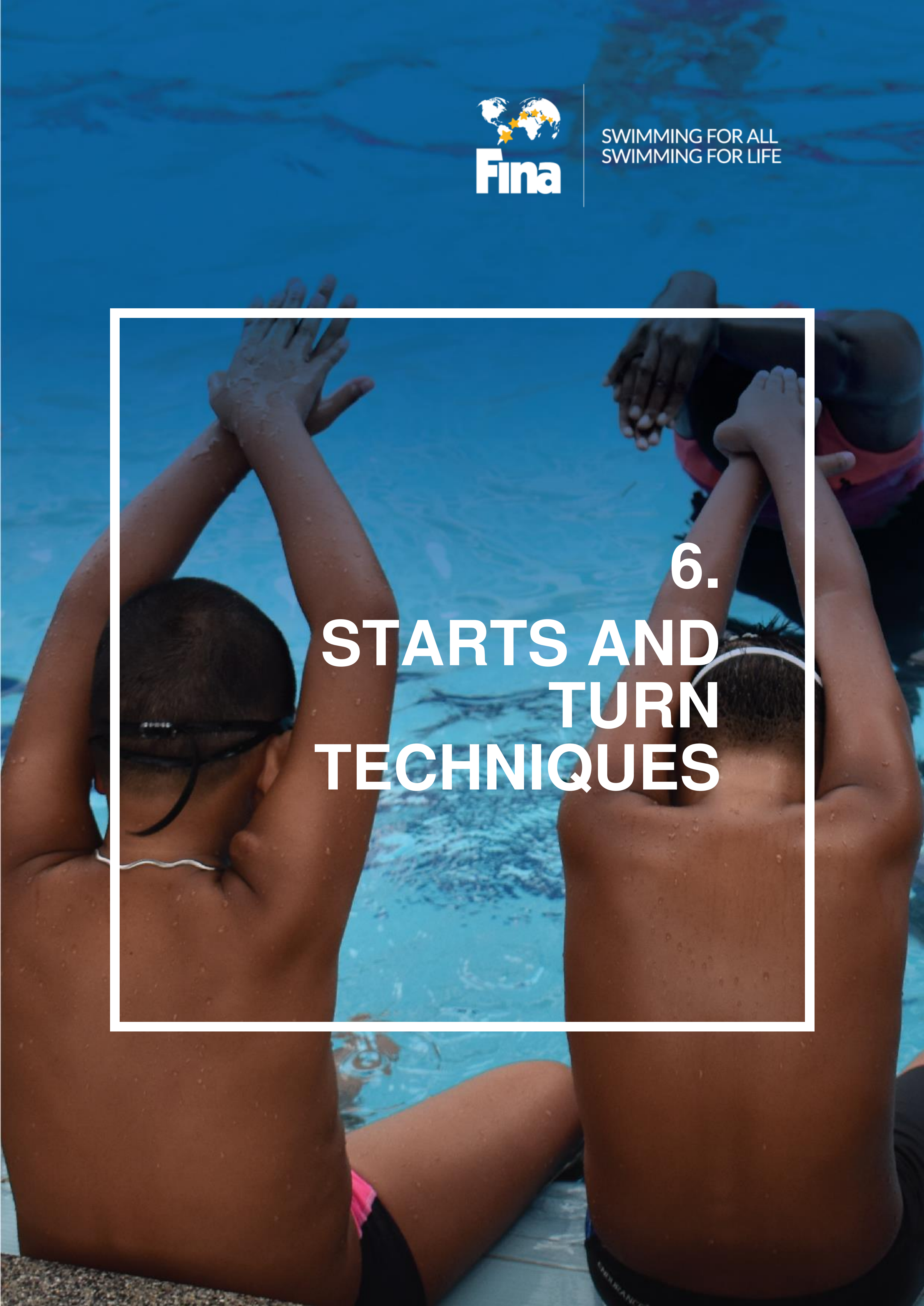

6. STARTS AND TURN TECHNIQUES

Swimming competition trial is broken down into several critical moments. Based on the literature, and according to the technical actions performed by the swimmer, we can highlight the following moments (Hay and Guimarães, 1983; Hay, 1988; Absalyamov et al., 1989): (i) the start; (ii) the swim itself and; (iii) the turn. Thus, the swimming teaching-learning process should address the techniques of start, swimming, and turn.

Both in the educational and competitive context, most of the sessions' time is spent teaching and perfecting swimming techniques. At an early stage, such an approach may be justified as debutants must acquire basic competencies.

Despite this type of intervention, a swimming competition trial is decided in several very particular aspects. The ability to react to the buzzer or the ability to change the direction after a turn by pushing off effectively the wall are some critical points for the swimmer's final performance. Therefore, starts and turns must be considered as relevant as swimming itself and worked with the same emphasis. Also, and especially the turning techniques, they allow the increase of the distances traveled in each teaching task with the concomitant increase in the student's work volume (i.e., increase in motor density and potential learning time).

6.1 Technical Model of the start techniques

The primary purpose of the start is to propel the swimmer forward as fast as possible as possible. As such, a good start is even more important the shorter the swimming distance (Cossar and Mason, 2001). In fact, in short-distance events, a good start (especially its time length) can distinguish similar swimmers in their way to victory. Also in relay events, the final result may be often influenced by the quality of the starts and transitions (Maglisho, 2003).

The traditional literature (Maglisho, 2003; Barbosa and Queirós, 2005; Barbosa, 2008) suggests the division in two types of starts, ventral (from the upper surface of the block) and dorsal starts (inside the swimming pool, with hands handling the block and feet on the wall). Due to the existence of relay events, it is also justified to distinguish the ventral start in individual events and start in the first slot of relay events (front crawl) and second, third and fourth slot. This differentiation is based mainly on the change of the start stimulus (from sonorous to visual, respectively) and consequently by their different predictability (Silva et al., 2005). Also, we must consider that FINA rules impose a stationary position to the start in individual events and relay's first slot. On the other hand, in relay changeover, the swimmer is allowed to perform movements, even for optimizing the body's push off, as long as does not leave the starting platform before the preceding swimmer has touched the end of the pool.

In the ventral start, there are several possible execution techniques to be adopted: (i) conventional start; (ii) grab start; (iii) track start; (iv) others, such as tuck start and other variants in the flight technique (e.g., Kristin Otto). In the case of the backstroke start two techniques of execution can be distinguished: (i) start in the variant closed chest and; (ii) start in the variant open chest.

The different start variants, particularly the ventral ones, lead to different angles of entry into the water and different depths in the underwater phase and should be adapted according to the corresponding swimming technique (Silva et al., 2005). According to the same author, the quality of the underwater phase and the speed with which the swimmer reaches the 15-meter mark is considered an indicator of the effectiveness of the start. Thus, for educational reasons, the start is generally segmented into four sub-phases: the initial position at the block; the push off from the block and the flight; the entry and the glide and; (Barbosa and Queirós, 2005; Silva et al., 2006) beginning of the swim. Each sub-phase has specific biomechanical functions to allow its interpretation and naturally the teaching and improvement of the gesture.
When referring to backstroke start, it is essential to consider that the rules oblige the swimmer to line up in the water facing the starting end, with both hands holding the starting grips being prohibited from supporting the feet on the gutter or bending the toes on the lip of the gutter (Barbosa, 2008).

6.2 Technical model of flipping techniques

All competitive swimming events with distances greater than the total length of the swimming pool involve the mastery of adequate turn techniques. The main rule determines that the swimmer to make the turn must physically contact the starting end of the swimming pool. However, the regulatory constraints are considerable and require significant attention from swimmers and coaches in the acquisition and improvement phases, aiming to execute the turn quickly and effectively.
Several types of turns are described: (i) open turning (freestyle to freestyle, butterfly to butterfly and breaststroke to breaststroke); (ii) flip turn (from front crawl to front crawl and from backstroke to backstroke); (iii) styles change (from butterfly to backstroke, from backstroke to breaststroke and from breaststroke to front crawl).
To facilitate the biomechanical diagnosis and the technical intervention of the different turn techniques, the following critical moments are generally considered: the approach; the tumble; the push off; the glide and; (Barbosa and Queirós, 2005; Silva et al., 2006) restart of swimming. From a competitive point of view, the turn time is considered as the sum of the time of approach to the wall, the time of contact with the wall, and the time of gliding phase to restart of the swim, what should occur until 15m (Sanders, 2002b).
Based on the technical model the flip turn, broken down into its sub-phases (approach, tumbling, push off, glide and restart the stroke cycle), Fernandes et al. (2005) refers for an initial learning phase, that is important that the swimmer reach a motor competence for turn, effectively linking the different subphases of the turn, mainly: (i) the hydrodynamic position during glide; rotations over the transverse and longitudinal axis; the active push off from the wall; the positioning of the body and segments for best transition into stroke.

6.3 The Teaching Model of start and turn Techniques

According to the teaching macro-sequence proposed by Barbosa and Queirós (2005), after the adaptation to the aquatic environment, specific starts and turns should be approached simultaneously with the particular swimming technique. The entry should be addressed when the student reveals the ability to jump heads first (i.e., the jump feet first is typically addressed during adaptation to the aquatic environment). On the other hand, the turn should be introduced when the student has a minimum resistance capacity to complete at least two swimming pool distances (round trip). So, it is justifiable to integrate turns with swimming itself. It will be of little use to approach the isolated turns when the student cannot yet swim.

In swimming teaching, it seems that the approach of the traditional start and closed chest start variant are the most regular. In the competitive Swimming training, in the last decades, a strong emphasis has been given to the teaching of the track start variant for ventral techniques and open chest variant for backstroke. In addition to the initial standstill body position, the feet and hands position due to the design and higher quality of the swimming pool edge and starting block may be additional points to consider.

Regarding the turns, aiming to facilitate the teaching-learning process, we will address essentially two techniques: (i) flip turn; (ii) open turn. In general, the open turning is taught first (from front crawl to front crawl, breaststroke to breaststroke and butterfly to butterfly). Then the next approach will be the flip turn (from front crawl to front crawl) with direct transfers to the turn backstroke to backstroke. Finally, when the student masters the formal swimming techniques, medley turns are then addressed.

The starts and turns teaching model are based, exclusively, on a global teaching model (Barbosa and Queirós, 2005). The impossibility of dissociating the movement to a more analytical type of task implies the execution of the whole movement in most of the proposed exercises. Unlike the swimming techniques, when teaching start and turns the global movement is taught although some of the actions are at an early stage of execution. Even so, it is essential that the addressed critical points be worked out progressively. For better understanding, the teaching of start should focus mainly on: (i) initial position; (ii) push off; (iii) flight and entry into water; (iv) glide and; (v) the beginning of swimming [transition into stroke]. Concerning the turns, the teaching elements can be divided into: (i) approaching the wall; (ii) tumble; (iii) push off; (iv) glide and; (v) the beginning of swimming [transition into stroke]. Thus, as much as possible, the analytical approach of start and turn techniques should be made concerning these phases. This is not always possible, and by way of example, it seems somewhat limiting to teach the flight phase in isolation without considering push off that precedes it.

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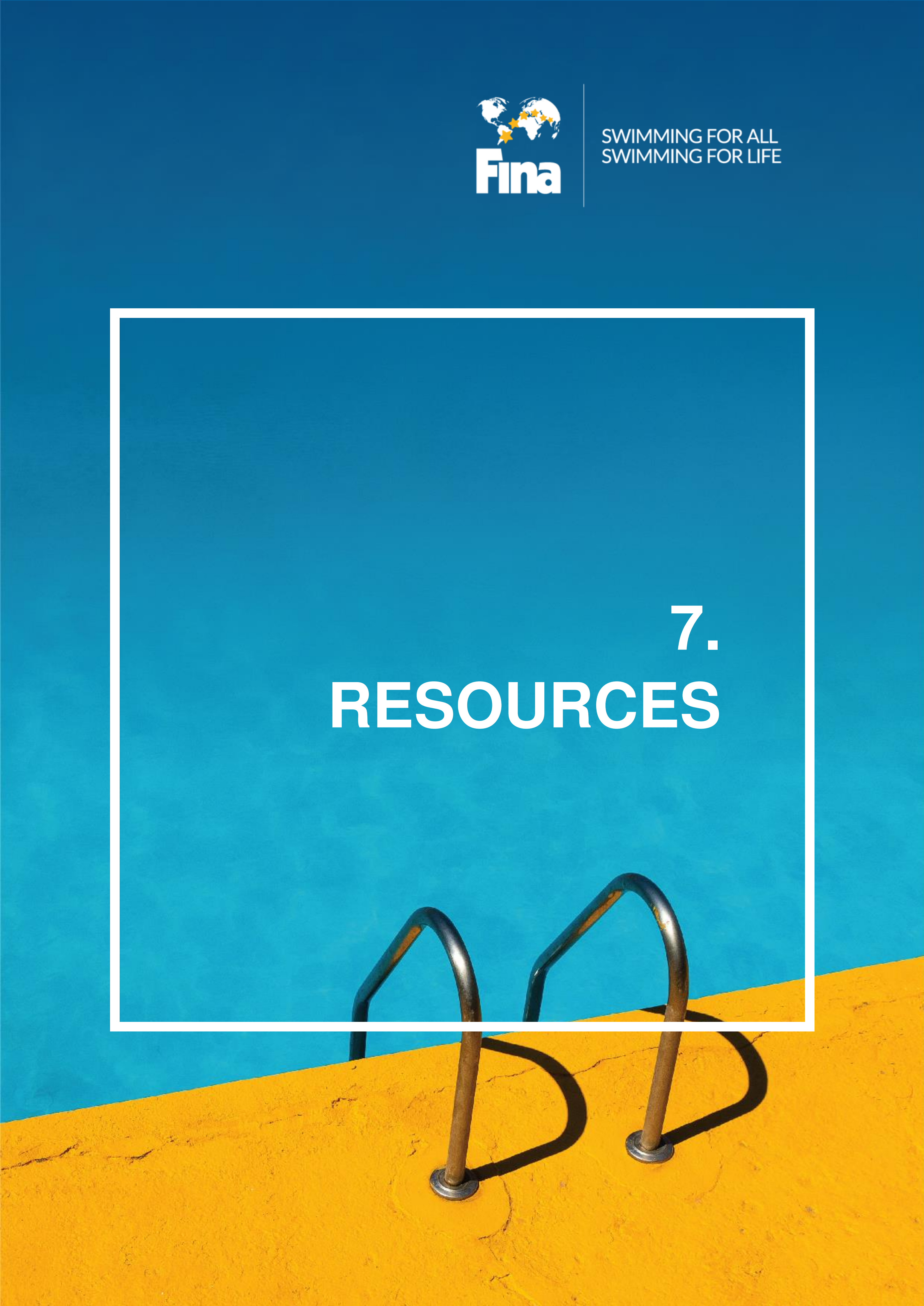

7. RESOURCES

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