APPROACHING PERFECT SWIMMING:
OPTIMAL FREESTYLE TECHNIQUE

By Rod Havriluk, Ph.D.

This document is part of The Approaching Perfect® series which explores the increasing use of technology to improve performance and enhance competitiveness. Although the series can be used by athletes at any level, swimmers who have already mastered some basic skills may be better suited to apply the principles presented throughout the program.

About the Author

Dr. Rod Havriluk is the president of Swimming Technology Research. Although he specializes in biomechanics, he has also maintained both a research and applied interest in skill learning and injury prevention. He is one of the most widely published authors on swimming technique and has made presentations to coaches and sport scientists in many countries.

Dr. Havriluk earned a Ph.D. in human performance from Indiana University in 1987. While at IU, he specialized in biomechanics under the direction of Dr. John M. Cooper ("the father of modern biomechanics" and inventor of the basketball jump shot) and learned from swimming legend Dr. James "Doc" Counsilman (scientist, oldest swimmer of the English Channel and coach of the most successful US Olympic Swim Team in history).

Rod's research has been published in many swimming publications including the *Journal of Swimming Research*, *Swimming Technique*, and *American Swimming Magazine*, as well as more general scientific publications like the *Research Quarterly for Exercise and Sport* and *Medicine and Science in Sports and Exercise*. He is a frequent conference presenter (FINA, IOC, Biomechanics and Medicine in Swimming, US Swim School Association), and is recognized internationally as an expert on swimming technique. He has lectured to coaches in many countries (e.g. USA, Brazil, Ecuador, Puerto Rico, Aruba, Saudi Arabia, Trinidad, Curacao). His research produced three US patents and prompted the development of software and hardware for instructing and analyzing swimming technique. He has been featured in books on advanced technology (*One Digital Day: How the microchip is changing our lives; Inescapable Data: Harnessing the power of convergence), magazines (PC Magazine; Swimming World Magazine.com)* and on TV (ESPN and "the Score"). His upgraded version of Aquanex+Video was selected as a finalist for *Product Design and Development's* 2003 Product of the Year and featured in *PC Magazine*.

He is a long-time member of the American Alliance of Health, Physical Education, Recreation and Dance; the American College of Sports Medicine; and the American Swimming Coaches Association. He is currently president of the International Society of Swimming Coaching. He serves on the advisory board of the Counsilman Center for the Science of Swimming at Indiana University; the editorial board of the *Journal of Swimming Research*; and the review board of numerous sport science journals.

Rod has a wide variety of swimming experience, including many years of coaching at the club and college level. He has also competed for most of his life, recently winning titles at a number of open water competitions. As a sport scientist, Rod has worked with thousands of swimmers and triathletes in team, clinic, and private instructional sessions. His client list includes Olympians, world champions, and world record holders.

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PREFACE

This book was prompted, in part, by the many misconceptions about freestyle technique, some of which have become "conventional wisdom." For example, ineffective arm synchronization (like catch-up stroke), counterproductive drills (like one arm freestyle), and nonscientific analysis procedures (like adopting a technique element of a champion only because he/she swims fast) have contributed to the proliferation of misconceptions. In contrast, all the technique elements presented in this book are based on principles of physics and decades of research, including thousands of trials using synchronized video and force-measurement technology.

Developed with the individual swimmer in mind, this book is based on more than 30 years of research and supported by specific experience in coaching (from age group to college level), consulting with domestic and international swim teams, and the author's work with individual swimmers at every performance level (from beginners to world record holders).

Although every technique element in this book has a scientific basis, every effort has been made to make each point understandable and easy for a swimmer to apply. As with anything worth doing, however, improving swimming technique is not for the un-motivated. Swimming is a complex skill, requiring many thousands of repetitions to change.

Keep in mind that improving your technique is the ONLY way to reach your full swimming potential and avoid the repetitive motion injuries so common in swimmers. Unfortunately, early success in competition usually results in an increase in training distance at the expense of continuing technique adjustment. (Swimming may be the only sport in which training ***quality*** (a focus on performing with an effective technique) is often sacrificed for ***quantity*** (training distance)! The greater the training distance, the more important it is to emphasize technique – both to avoid injury and reinforce positive technique elements.

At Swimming Technology Research, the science behind every idea is paramount. At the same time, not every swimmer shares that fascination with the underlying biomechanical, physiological, and anatomical foundations. For this reason, effective technique is presented first in this book – much of the scientific basis is saved for the chapter on advanced concepts at the end.

This book includes several icons to help you (swimmer or coach) obtain the information that is most important:

CUE The CUE icon specifies information about the position and motion of body parts that you can see or feel while swimming.

The clipboard symbol indicates information of special interest to coaches.

TIP: The TIP icon alerts you to key information or a special way for controlling a technique element.

The whistle signals a drill or exercise to incorporate into your training.

For those of you interested in the science behind the ideas, the appendix includes summaries of research, as well as links to additional resources and reference material.

STR research is ongoing and your insights/comments about applying the concepts and strategies are always welcome. Contact Dr. Havriluk at havriluk@swimmingtechnology.com.

CHAPTER ONE: INTRODUCTION TO APPROACHING PERFECT

This program will introduce you to the optimal technique of swimming freestyle. The program features a technology-generated biomechanical model to demonstrate perfect technique in the freestyle stroke, something not yet found in any "human" swimmer.

Figure 1. A biomechanical model of optimal swimming technique.

Most programs use a top swimmer as a model. While research clearly shows that faster swimmers have more effective technique than slower swimmers, research also shows that even the fastest swimmers have technique limitations. For this reason, the model does not replicate any individual's technique, but instead is a composite of all the most effective elements of technique.

The program:

- Uses the model to demonstrate optimal technique from above and below the surface;
- Presents visual cues (what the swimmer sees) as well as kinesthetic cues (what the swimmer feels) that will help a swimmer monitor, control, and change technique;
- Provides a checklist for stroke analysis (designed to be used by swimmer, parent, or coach);
- Suggests stroke drills and exercises that focus on specific stroke elements; and
- Gives tips on using equipment to isolate or exaggerate specific stroke elements (to bring them to a level of awareness that the swimmer can recognize, understand, and control).

After completing this program, you will be able to:

- Identify head, arm, and leg cues for each key position within the stroke cycle;
- Determine what changes are needed to improve technique;
- Evaluate technique throughout the entire freestyle stroke cycle;
- Understand how an effective technique will help avoid injury;
- Understand how a more effective technique will improve performance;

- Use a simple feedback form to record current swimming technique and identify needed improvements; and
- Use cue-focused practice to accelerate your technique improvement and swim faster.

Bonus: *Applying* what you learn will help reduce both your effort level and the chance of injury, and ultimately, make you swim faster.

Key Skill-Learning Concepts

*Principles of physics, research, and competition have clearly determined the mechanics of an optimal freestyle technique. However, humans must **learn** the skills. A number of skill learning strategies can be used to master these technique elements as quickly as possible.*

Start Slow to Swim Faster

At first glance, swimming slow to get faster doesn't seem to make much sense. But, research in an increasing number of sports and performance activities clearly shows that this is true. Experts insist that mastery of any sport, musical instrument, or movement-based skill requires "deliberate" practice. Swimming strokes must be performed at a speed slow enough to allow focus on individual elements of technique by using cues that specify the position or motion of body parts. It is strongly recommended that swimmers initially swim at a speed where they can be sure they are complying with the cues.

TIP: A general guideline to improve control is to move the hand through the entire stroke cycle as slowly as possible with a continuous motion – i.e. with no hesitations or gliding.

Cue-Focused Practice

It simply is not possible to improve technique by swimming longer workouts. To learn why this is true, let's start with the basics.

To begin with, swimming is difficult. The motions that humans naturally use on land are generally not effective in the water. Because of this, everyone needs to ***learn*** to swim.

That learning process is further complicated because swimming involves continuous motion of both arms, both legs, and the torso - - while the body is submerged.

This makes it all but impossible to gain all the skills needed to optimize technique at one time. Instead, swimming instruction - from basic to advanced skills - is most successful when a swimmer can focus on a limited number of technique elements at a time. This can be done most effectively by using cues - precise information about the orientation of body parts at a specific point in the stroke cycle. Once a swimmer

shows the ability to focus on one or two cues (and begins to exhibit both mastery and consistency), additional cues can be introduced.

There are three types of cues – visual, kinesthetic, and auditory.

- A **visual cue** is something you can see - for example, the hand passing beneath the head during the freestyle pull.
- A **kinesthetic cue** is something you can feel - for example, the water level at your hairline.
- An **auditory cue** is something you can hear – for example, the arm entry.

All three types of cues are critical tools for learning any complex movement or skill. Auditory cues, however, play a very minor role in swimming compared to visual and kinesthetic cues.

One of the many benefits of using cues is that you can implement a "standard language for communication" with your team. Cues simplify the information (by explaining a position or motion with a short phrase) and minimize the chances of miscommunications.

Skill-Isolation Drills

Drills can also accelerate skill learning. In particular, drills that isolate a specific technique element (skill-isolation drills) make it easier for the swimmer to process the information that is critical for control. Drills can improve focus on a specific cue. Drills can exaggerate a position or motion so that a technique element rises to the level of the swimmer's awareness. Drills can also push a swimmer to use the full range of motion at a joint.

Movement Control, Permanency, and Automaticity

Focusing on one or two cues at a time by seeing or feeling something specific is a proven way to expedite the learning process. However, it will still require many repetitions (i.e. tens of thousands) of each skill to develop permanency. Once a skill is "permanent," it becomes automatic and does not require the same level of mental involvement. (We have many "permanent" skills already: walking, driving a car, and riding a bicycle are examples.)
Although you won't hear much about it on a pool deck, technique changes require a swimmer to process a great deal of information derived from the principles of physics – specifically, biomechanics and hydrodynamics. This is supported by a substantial body of research that shows how swimmers can best apply these principles.

This program aims to do just that. In addition to accessing volumes of swimming research conducted by experts, Swimming Technology Research has refined technique learning strategies using thousands of trials of synchronized video and force analyses. This research is the basis for the Approaching Perfect program and the performance model it presents.

Skill Development Process

The development of effective swimming technique is an involved process. Fortunately, we have principles of physics (biomechanics and hydrodynamics) and decades of research to guide us in developing an optimal model. Skill-learning acceleration methods (SLAM) are critical to rapidly acquiring the skills exhibited by the model. As more skills are mastered, coach-directed conditioning provides the swimmer with training at faster speeds and with fatigue. Synchronized video and force data feedback show the swimmer how well he/she is complying with the model. Adherence to this scheme produces faster performance times.

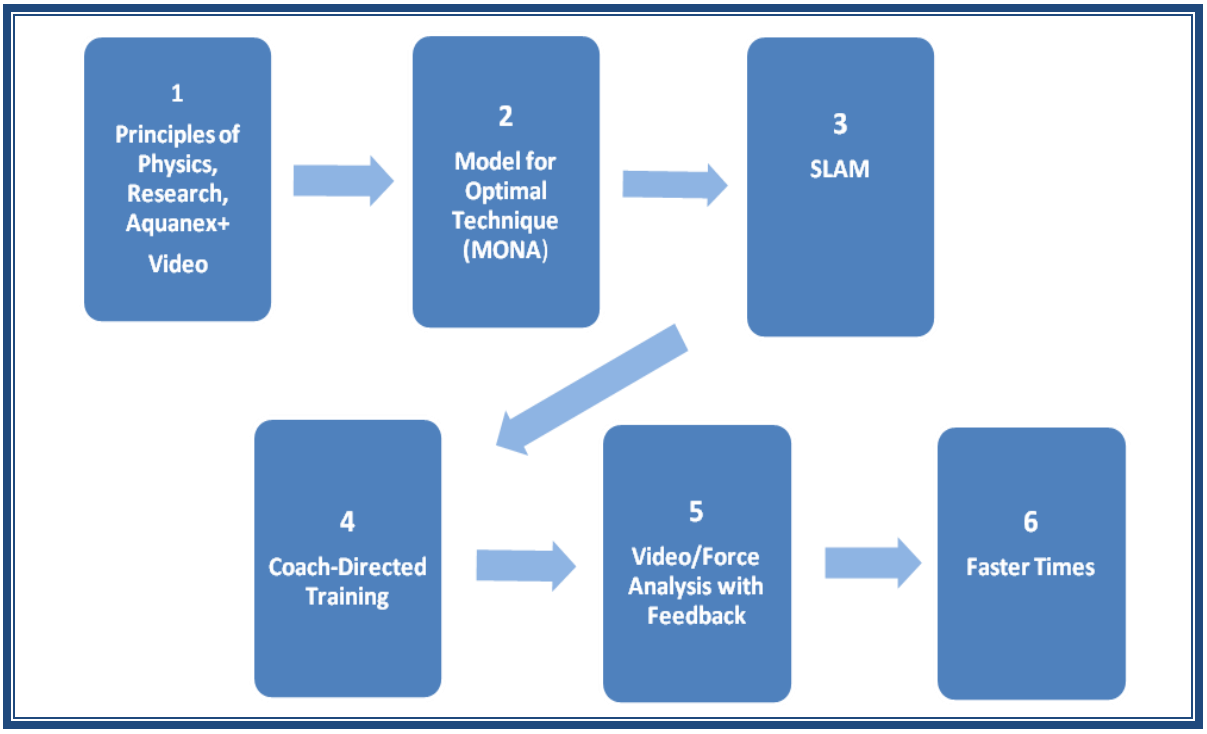


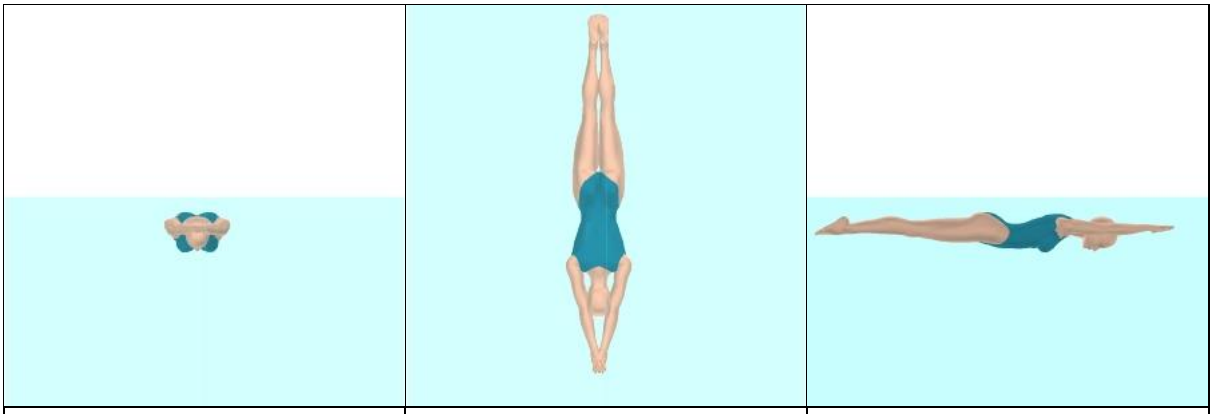
Figure 2. A scheme for skill development.

Having a model for optimal technique is vital, but learning strategies that allow for skill development are just as important. With effective strategies, swimmers make technique adjustments to conform to the model, using cue-focused practice. Using the cues for feedback, individual swimmers make technique changes permanent when they can maintain the technique changes throughout a routine or coach-directed workout (i.e. at faster speeds and with fatigue). A video/force analysis reinforces the changes and identifies additional limiting factors. The change cycle can then begin again with cues for new skills.

Once the new skills are mastered (that is, when the changes become permanent), faster swimming will result.

CHAPTER TWO: HEAD, BODY, AND LEG POSITION

The most basic goal for optimizing technique is to swim as fast as possible with as little effort as possible. Minimizing resistance and maximizing propulsion help to achieve this goal. First, consider the body position that minimizes resistance – the streamline, as shown in Figure 3 below.



Front View	Top View	Side View

Figure 3. The most basic position for swimming – the streamline.

One way to evaluate the streamline is to draw an oval around the shoulders (in the front view image). If all the body parts are within the oval, the cross-section of the body (the area that is perpendicular to the horizontal direction of motion) will be minimal, and so will the resistance.

A second way to evaluate the streamline is to note how well the orientation of all body parts makes the water flow around the body with minimal turbulence. The more the body is shaped like a spear, the better the water will flow.

An effective streamline exhibits compliance with nine cues. Only one cue is visual (body part orientations you can see) while eight cues are kinesthetic (body part orientations that you can feel).

CUE

For an optimal streamline position:

- The ***visual cue*** is to see the bottom of the pool directly beneath the head.
- The ***kinesthetic cues*** are to feel:
  1) one hand on top of the other
  2) fingertips pointing horizontally at the pool wall
  3) elbows locked
  4) upper arms squeezing the ears
  5) back arched
  6) legs straight
  7) feet together
  8) toes pointed

A subset of these cues is sufficient for most swimmers. For example, kinesthetic cues 1, 4, and 8 are adequate for many swimmers. However, some individuals may require attention to all nine cues.

TIP: Initially, focus on two cues for the streamline – one hand on top of the other and upper arms squeezing the ears. The hands can be positioned before pushing off from the wall so after the push-off it is only necessary to position the upper arms.

While the streamline is optimal for minimizing resistance, a swimmer cannot maintain this position and generate any propulsion. It is helpful to keep in mind that as limbs move to generate propulsion, maintaining a position as close to streamline as possible will help to get the best of both worlds – maximum propulsion and minimal resistance.

This ***does not*** mean that the body is ever in a streamline at any point in the freestyle stroke cycle. This ***does*** mean that a swimmer will benefit when swimming with a body orientation that is relatively close to a streamline.

The best way to reinforce the streamline is on every push-off from the wall. Assume the streamline as soon as the feet separate from the wall. It is best to maintain a motionless position as you check compliance with all the cues for the streamline. Initially, checking nine cues (or a subset of cues that works for you) may require several seconds. With practice, that time will decrease. When mastery occurs, you will be in compliance with all nine cues as the feet leave the wall.

Swimmers often get lazy (or at least inconsistent) about hitting all the cues of an optimal streamline on every push-off. Constant reminders before each push-off and feedback after each push-off are necessary to achieve consistency. Remember, this is the most basic position for successful competitive swimming. A swimmer who ***has not*** mastered the streamline is likely to struggle with more advanced skills. A swimmer who ***has*** mastered the streamline shows the body control necessary to progress to more advanced skills.

Flexibility is an issue in achieving an optimal streamline. Some swimmers, particularly adults, lack the range of motion at the shoulder to make the upper arms squeeze the ears. A lack of flexibility may be a reason to not be compliant with certain cues. However, realize that every time you get into the streamline you are performing a flexibility exercise that can increase the range of motion. A sufficient number of repetitions (and it could be many thousands!) will help you achieve an optimal streamline.

In the following series of images, you'll be introduced to "perfect technique" that incorporates optimal head and body positions throughout each arm and leg phase of

the freestyle stroke. (There's a lot happening in each second – just like it does in the water.) You will also be introduced to specific cues to check your own technique and receive several tips to help you perfect your technique.

In the next few chapters, we'll show you exactly what the model is doing with her head, body, arms and legs in each phase of the stroke. Continue by carefully reviewing the images that follow. Note that this information is organized by **key positions** (for the head, legs, body, and arms), **stroke phases** (exit, entry, pull, and push), and **breathing motion**.

Key Freestyle Positions

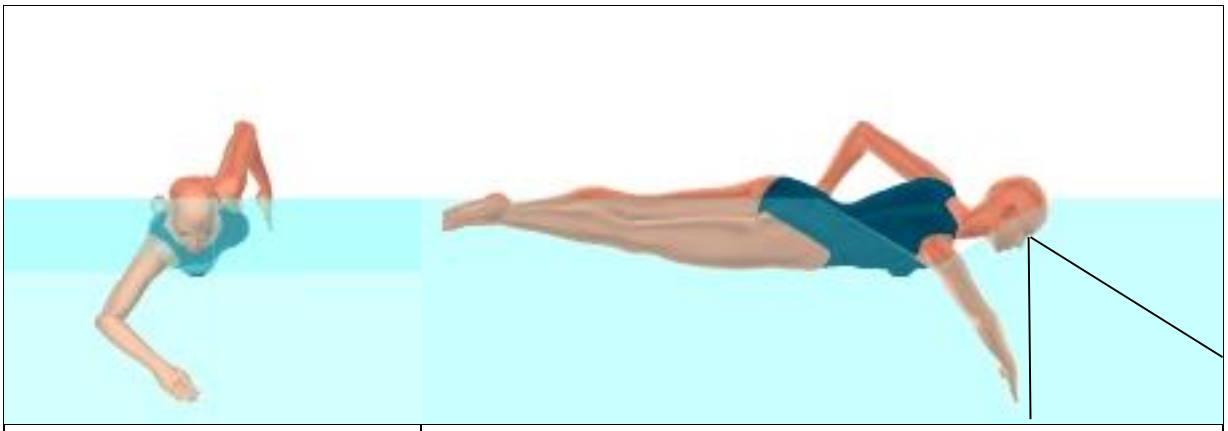
To say that the following positions are "key" is an understatement. A swimmer, who masters the cues for the head, arm, and leg positions below, will have (at the least) a relatively effective technique.

Non-breathing Head Position

The non-breathing head position is critical, and not just for the sake of the head. If the head is optimally positioned (and motionless), other skills will be easier to evaluate and control.

CUE For an optimal non-breathing head position:

- The ***visual cue*** is to look forward at a 45° angle so that both the wall at the end of the pool and the bottom of the pool are within your view.
- The ***kinesthetic cue*** is to feel the water level at your hairline.



Front View	Side View

Figure 4. The non-breathing head position with lines showing the boundaries of a typical field of view (side view).

Key Points:

- The exact position of the water level on the forehead primarily depends on two factors: body composition and swimming speed. Very slight adjustments may be necessary.

- Swimmers with a lower proportion of body fat or a lower swimming speed may need to lower the head slightly (by flexing at the neck) so that the water level is slightly above the hairline.

- Swimmers with a higher proportion of body fat or a faster swimming speed may find they can breathe more easily by raising the head slightly (by extending at the neck) so that the water level is just below the hairline.

- The head position remains fixed throughout the non-breathing stroke cycle and there is no vertical, lateral, or rotational movement.

One of the many misconceptions about swimming technique is that the head must be submerged for the legs to stay behind the shoulders. Although lowering the head may help to raise the legs, breathing then requires excessive head motion that distorts the body position and increases the body cross-section. Since the spine is closer than the head to the legs, ***arching the back*** is a much more effective way to control the leg position.

Even many experienced swimmers have minor head motion during non-breathing stroke cycles. Very often, head rotation is synchronized with torso rotation. While a slight amount of head motion will not have a major impact on swimming speed, it is vital to control because of the impact on tracking other skills. A swimmer can be much more certain of what he/she sees and feels if the head (the primary frame of reference) is motionless. It is also very common for swimmers to synchronize downward head motion with the arm entry. This is natural, but counterproductive.

Leg Position

Once the head is in an optimal position, it is much easier to orient the rest of the body. Arching the lower back lifts the legs to bring the heels to the surface. If the legs stay behind the torso (as in the front view of Figure 4), resistance is minimal. The smaller the swimmer maintains the area of the body perpendicular to the direction of motion (the body cross-section), the lower the resistance.

CUE For an optimal leg position:

- the ***kinesthetic cues*** are to feel:
  1) the legs straight
  2) the toes point
  3) the back arch so that the heels break the surface on every kick upbeat.

TIP: Every time you push-off from the wall, maintain the streamline position until you feel the heels at the surface. (Arch the back, if necessary.) Then, it is only necessary to maintain that leg position to feel the heels break the surface on every upbeat. Note how the model's heel breaks the surface in the side view of Figure 4 above.

Key Points:

- Even if the head and body are optimally positioned, there is no guarantee that the legs will stay in line with the torso to minimize the cross-section.

- Very often, the legs will drop below the torso and generate excess resistance. This is fairly common in adult males.

- If necessary, arch the back so the heels rise to the surface. This will keep the legs behind the torso to minimize the cross-section and, therefore, resistance.

- Avoiding excess knee bend and foot separation are critical cues for maintaining a leg position with minimum resistance.

Body Position

If the swimmer has an optimal head and leg position, the body (torso) position will probably be effective. A front underwater video can confirm that the cross-section is minimal. If there is an issue with the torso, adjustment of the head or legs will usually make the necessary correction. Note the front view image of the model in Figure 4.

An optimal body position and optimal use of energy depends on using less muscular effort rather than more. Research shows that contraction of abdominal muscles can have a negative impact on performance. Research also shows that more skilled swimmers only use the muscles that are critical for a movement, while less skilled swimmers also activate unessential muscles.

Key Points:

- If the head is motionless, it is much easier to maintain an effective body position throughout the entire stroke cycle.
- To minimize resistance, the body must present a minimal cross-section in the direction of motion.

- To minimize the cross-section, rotate the shoulders and hips together.
- Torso rotation is best synchronized with the arm entry – i.e. as the arm enters, the torso rotates downward.

TIP: There are many references to "body length" in the literature. It is true that a longer body has a lower drag coefficient and will, consequently, go faster (all other factors being equal). However, ***trying*** to make the body longer by stretching the arm in front of the body can twist the torso, stress the shoulder, and slow the stroke rate.) Body length is determined by body height. A swimmer will make the best use of his/her height by complying with the cues for the head, arms, and legs.