

## **OPEN WATER**

### **The history, science and self-help of swimming**

**By Mikael Rosén**

The life of an ambitious swimmer is truly a harsh one. Aching muscles, ridiculously early mornings and a crazy amount of exercise constitute a big chunk of everyday life. However, swimming is so much more than just tedious work in the pool while struggling to get enough oxygen. Swimming also involves fantastic adventures, fascinating research and massive changes in the world of international relations.

Open Water uses both history and science for looking at swimming from eight different perspectives. These perspectives range from the perfect bodies of swimmers via 90-year-old world record holders and 12-year-olds who swim faster than Olympic triathletes to penguins swimming much faster than you think. Here you also encounter stunning swimming fates and big winners in the genetic lottery, such as Michael Phelps and Sarah Sjöström.

Open Water also provides you with great assistance when it comes to developing your own swimming – regardless of talent or ambition.

## **OPEN WATER**

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## Chapter 1: Back to the Future

“My technique was perfect and my records will never be beaten.”

– Johnny Weissmuller

### **Amsterdam, August 11, 1928.**

Everyone at the arena knew that Johnny Weissmuller was the greatest swimmer in the world. In fact, he'd only lost a single race throughout his entire career. This happened at Weissmuller's first major competition when he, still a teenager, was unable to muster enough power to last 440 yards. He handled this defeat simply by never mentioning it, instead coining his selling slogan: “I never lost a race.”

The 1928 Amsterdam Olympics was his last competition. At this time, both swimmers as well as other athletes were forced to choose between competing and making money. As Weissmuller was the best-known swimmer in the world, three New York businessmen wearing top hats and pinstripe suits had successfully enticed him into signing an advertising contract for their brand of swimsuits. All Big Johnny had to do was to go to Amsterdam and win the gold medals in 100 meters freestyle and the freestyle relay race.

The great Weissmuller confidently walked by the Olympic pool as if he'd done nothing else for his entire life. He stood 6'4" tall with shoulders as wide as those of a heavyweight boxer and a smile that reminded people of the ivory keys of a piano. Wearing a custom-made cape over his shoulders, he was joking around with friends and dazzling his admirers while waiting for the start signal. He and another tall favorite, Stefan Baranyi from Hungary, took up a lot of space behind the starting blocks. Just like Weissmuller, Baranyi was also born in the Habsburg Empire, even though his place of birth (Timisoara) is now located in Romania. Maps are frequently redrawn by wars. Nobody noticed the Japanese man standing next to these tall favorites. He was about a head shorter and had a small beard. Well-informed audience members looked up in disbelief as the name of the qualified Japanese swimmer was read out loud. Could this short, funny-looking man really be the swimmer from the Land of the Rising Sun who'd been portrayed as Weissmuller's biggest competitor for the gold?

Minutes before the start, however, the audience shifted its attention from the charismatic Weissmuller to Katsuo Takaishi, which was the Japanese athlete's name. Takaishi warmed up with a gymnastics routine never seen before in the context of swimming: He folded himself over like a pocket knife and spun his arms as if he didn't have any cartilage or restrictive connective tissues. Takaishi had a modest smile on his face and bowed to the audience as if they were sitting in a martial arts dojo.

The start signal went off and Weissmuller and Takaishi immediately took the lead. The audience could now witness the masters of two vastly different styles of swimming swooshing their way through the pool. The large American arched his lower back and held his head and shoulders high. The smaller Japanese swimmer seemed larger in the water than when standing next to the pool. He had a lower position in the water, almost below the surface, and cut through the water like a sword fish.

Halfway through the race, Takaishi appeared to be in the lead. The audience gasped in surprise and people sitting next to one another, who would never have talked to one another under different circumstances, now experienced the miraculous connection people encounter when

attending special events. More and more people got up, and by the end of the race the expensive seats had turned into a mere standing section.

However, halfway into the second and final pool length, the people in the stands realized that there would be no great upset. Takaishi was running on an empty gas tank and he was no longer able to keep up with the American. In the end, Weissmuller won in the same great style he liked to emphasize in his tales. His set a new Olympic record: 58.4. Stefan Baranyi also barely beat the exhausted Takaishi: 59.8 against 1:00.0.

Katsuo Takaishi became the first Asian male swimmer to win an Olympic medal and he was passionate about cracking the code for swimming faster. Even if Amsterdam was the highpoint of his career as an active swimmer, his bronze medal was not to be his most important mark on the history of swimming.

When Takaishi arrived at the next Olympics, he did so as the head coach of the Japanese team. And a lot had happened in those four years. The great Johnny Weissmuller didn't participate, even though the Olympics were held in his new home town of Los Angeles. The King of Swimming had signed a Hollywood contract with Metro-Goldwyn-Mayer to shot Tarzan movies. This was a career that gave him plenty of opportunities to talk on the radio and in newspapers, where he could make unabashed statements such as: "My technique was perfect and my records will never be beaten."

As customary when hosting the Olympics, the Americans prepared for a massive show. And there were definitely grounds for optimism. The men had won two gold medals, one silver medal and two bronze medals in the five events of the 1928 Olympics. The United States had also won the relay race. So, just how successful would the Americans be this time, now that they didn't have to take the long trip to Europe?

The Olympics were held in Antwerp in 1920, in Paris in 1924 and in Amsterdam in 1928. With its four steam turbines, the Atlantic steamer Mauretania had a maximum speed of 24 knots and was able to take 2,165 passengers living in crowded quarters from New York to Southampton in just five days. However, the American Olympics team didn't travel on the Mauretania in 1928, but had to settle with SS President Roosevelt with a maximum speed of 13 knots. This ship was considerably more modest in terms of comfort and would sixteen years later be used for landing young American soldiers on Utah Beach on D-Day. For the American Olympic swimming team, the journey meant ten days without being able to practice in the water. Instead, they had to make do with gymnastics and light jogging on the deck while listening to Weissmuller's fantastic stories.

The Olympic idea of gathering athletes from all around the world was threatened by a global shipping crisis. Not only did the sinking of the Titanic in 1912 give both passengers, shipping companies and ship designers a lot to think about, in 1921 the United States Congress unanimously adopted a law limiting immigration from Europe. The number of immigrants to the promised land in the west exceeded 800,000 in 1920, whereas only 309,000 hopeful people crossing the Atlantic were allowed entry into the United States during the two following years. The shipping companies were struggling, which, in combination with the Great Depression that began with the Wall Street crash of October 1929, meant that hosting the Olympics in the United States was a prerequisite for being able to mobilize a large American team. Yet another Olympics in Europe would have minimized the American presence at the games. From having fielded Olympic teams consisting of 200–300 athletes in the three Olympics of the 1920s, the United States was now able to assemble 474 athletes for the 1932 Los Angeles Olympics. Twenty-two swimmers in 1928, nine men and thirteen women, increased to sixteen men and ten women in 1932. Never before in the history of the Olympics had a nation's men's team been this big. The world of swimming was

about to witness success! And the world of swimming witnessed. The entire world of sports witnessed. When it came to the men's results at the tenth Olympics, one nation crushed all competition to an extent never seen before. But the ones astounding the world were not the Americans. It was the Japanese.

After having returned from Amsterdam, Katsuo Takaishi had decided to help other swimmers. And with him as the head coach, the Japanese were now in a position to soundly defeat every opponent in Los Angeles. The aquatic samurai from the Land of the Rising Sun won both the gold and the silver medals in every event, with the exception of 400 meters freestyle. They won the relay race with the 12 seconds – despite the fact that the Americans beat their old world record. Japan won all three medals in 100 meters backstroke. The average height of the Japanese winners was a modest 5'7" – in other words tiny compared to the Americans. So what made this overwhelming dominance possible? Had the Japanese practiced harder than the Americans? The Americans were naturally eager to find out the reasons behind this Japanese transformation. Dr. Thomas Cureton at the University of Illinois, also known as the father of athletic physiology, got to work analyzing the available information and released a report two years after the Los Angeles Olympics, where he identified four key areas:

- 1) ATTITUDE. The Japanese team had substantial and visible financial support from the government, which resulted in serious and dedicated swimmers.
- 2) SWIMMING TECHNIQUE. The Japanese had developed the crawl technique by studying and developing the American technique.
- 3) FITNESS. The simple, classic Japanese diet resulted in the swimmers being full without over-eating. In some cases, they practiced four times as hard as the Americans.
- 4) ANATOMY. The lightweight Japanese were better at floating than the heavier Americans. They were also more flexible than anyone had ever seen in the world of swimming.

Prior to the Los Angeles Olympics, Cureton had argued that the body must be kept flat in order to be a fast swimmer. This was the Weissmuller way. At the Olympics, the superior Japanese had instead chosen to swim while rotating their bodies. Even though he was of sound mind, Cureton was unable to see the Japanese rotating their bodies as being an explanation for the American defeat. In his report, he instead argued that Weissmuller's technique of holding his head high and his shoulders flat was superior. After all, Weissmuller's world records remained in place until 1944–45 when several of them were beaten by Alan Ford using Weissmuller's technique.

In a LIFE Magazine interview, Ford revealed the secret behind his success as rotating his shoulders even less. Ford and his coaches at Yale University said that the shoulders should be placed so high that they barely touched the water. If, however, the shoulders were to end up in the water, they would then work as break pads. The same also applied to the head, which was also to be placed high. Ford's interview in LIFE had a massive impact and resulted in an entire generation of young swimmers making their way through the water in a style reminiscent of amphibian planes taking off.

The Second World War resulted in the 1944 Olympics being cancelled. Alan Ford was drafted into the Navy quite late in the war, after his world records, where he served as a second lieutenant. While serving, Ford lost twenty pounds and smoked two packs of cigarettes a day in order to cope with the horrors of war. He left the Navy in the spring of 1948 to resume his swimming and engineering studies at Yale. Half a year later, after having put out his Chesterfield cigarettes, he won a silver medal at the London Olympics. In 1966, Alan Ford was elected into the International

Swimming Hall of Fame. The festive ceremony was interrupted by loud booing emanating from the back of the room. People wanted to know who was behaving so disrespectfully and turned around. Only to be greeted by Johnny Weissmuller.

The year following Cureton's report, another book was published: Katsuo Takaishi's *Swimming in Japan*. Here Takaishi argued that although the Japanese had certainly practiced hard, the secret behind their success was primarily their improved technique.

So, what did Takaishi's revolution consist of? In order to understand this, we need to go through the mechanics of swimming, because people were already at this time aware of the physics affecting the process of swimming.

## WATER FOR SPEED AND WATER AS A BRAKE

Swimming is unique insofar as swimmers are positioned in a liquid that they try to grip in order to move their body forward. Water doesn't offer the firm resistance of solid ground, something runners are able to benefit from when moving forward. Water is also 800 times denser than air, which forces the swimmer to try to minimize the resistance of his or her body in the water.

The form of resistance that is the easiest for a swimmer to influence is that of friction. A shaved and smooth swimmer is able to slide faster through the water compared to a swimmer with a hairy body. The first swimmer to shave his legs is said to have been the Australian Jon Henricks in 1955. The following year, a fellow Australian, Murray Rose, did the same when Australia won five of the seven men's events at the Olympics held in their backyard, in Melbourne.

That's why razor manufacturers have had a close relationship with elite swimmers ever since 1956, with one short break. Between 2000 and 2009, it was common for swimmers to compete in full-body swimsuits. The reason being that these suits made them faster; not just by reducing friction, but also because the fabric contained rubber. Thus the laborious shaving ritual the day before the competition came to be replaced by an equally laborious dressing ritual – squeezing your way into the tight suit could take more than 30 minutes. Using competition swimsuits containing rubber has been banned since 2010, and now they're not allowed to extend farther down than the swimmer's kneecaps. This resulted in the return of the razor manufacturers. According to *Fortune Magazine*, Gillette is said to have sponsored the star Ryan Lochte to the tune of \$300,000 during the Olympic year of 2012.

## RULES CONCERNING EQUIPMENT

### 1. Swimsuit

Is not allowed to be made of a material other than textile. The floating effect must not be greater than 0.5 newtons in a vacuum. Double swimsuits or two-piece swimsuits are not allowed. However, the same swimsuit may contain two layers of fabric. All in all, however, the thickness cannot exceed 0.8 mm. They can't have Velcro, zippers or seams forming external patterns. Their design can't be of a type that may be perceived as indecent. Otherwise, there are no restrictions as to colors or patterns.

### 2. Swimming cap

Is not allowed to be attached to the glasses. Must follow the contours of the head without attempting to create a sharp, hydrodynamic shape. Is not allowed to have any structure, but must be smooth and with a maximum thickness of 2 mm. Must be made out of a soft material. Helmets are prohibited.

### 3. Swimming glasses

Are not allowed to be attached to the swimming cap. The purpose is to protect the eyes of the swimmer from water without offering a hydrodynamic advantage.

### 4. Measurement variations on swimsuits

Pool: The men's suits are not allowed to extend above the navel or below the knee. The women's suits are not allowed to cover the neck, the shoulders or extend below the knees. Open water: The same rules apply as those for women's pool swimsuits, with the difference that the suits may extend down to the ankles.

### 5. Wetsuit

In triathlon, competitors usually wear wetsuits, based on the water temperature. The same exemption from international rules also applies to open water competitions in Sweden. In swimrun, there are not a lot of restrictions; hand paddles and pull buoys are for instance permitted.

### 6. Other equipment

Must be approved by the International Swimming Federation (FINA) at continental or global championships. The label in the suit indicates if they are approved.

Water resistance is not only affected by the smoothness of the swimmer's body surface, but also by his or her shape, size and speed: A pointy vessel results in less resistance than a rounded one. This is easy to imagine if we consider the design of competition kayaks.

A large swimmer disturbs more water molecules than a small swimmer. The body surface is thus the determining factor here, where slim swimmers create less resistance than swimmers with more body fat. At the same time, in spite of creating more resistance, tall swimmers are better suited for swimming fast based on the fact that he or she is able to create more forward driving force.

Forward Driving Force – Resistance = Speed

It's easy to understand that the speed of swimming increases if the arm stroke frequency increases, given that each arm stroke retains the same length.

Stroke Length × Stroke Frequency = Speed

Newton's second law of motion illustrates the importance of the swimmer not losing speed:

$$F = m \times a$$

The momentary speed varies for all swimmers. The pull of the right hand results in a burst of speed that then decreases until it is increased by the left hand. This becomes particularly noticeable in a tired butterfly swimmer who visible sort of "saws" his or her way through the water. The ability to maintain your speed as much as possible in-between strokes is called moving inertly and is a variable characterizing the best swimmers.

In his book *Swimming in Japan*, Katsuo Takaishi describes freestyle strokes with a kind of precision that is still surprisingly relevant some 80 years later.

Entering the hand

Takaishi believed that the process of entering the hand was key for the swimmer's forward driving force. The hand was not supposed to be stretched all that far forward, but was supposed to grab the water at an earlier stage in order to avoid the lift force created when pushing the hand down far in front of the head. According to Takaishi, the feeling involved in executing this move was absolutely crucial.

This principle has played a role in the positive developments of freestyle swimming during this century. It used to be said that after entering the water, the arm should be pulled straight down in order to retain as much of the kinetic energy as possible. In recent years, however, swimmers have been pulling farther away, as it has been found that the fastest path from lift force to forward driving force is farther away. The technique also results in the swimmer becoming better at utilizing his or her strong, hardy back muscles and thus using his or her weaker and more delicate shoulder muscles to a lesser extent.

A comparison between the best female swimmer of the 1960s, Dawn Fraser, and Sarah Sjöström, who 50 years later holds a number of world records.

Weissmuller had a much flatter swimming technique compared to that of Takaishi and later swimmers.

### Body rotation

Western coaches and experts, as prompted by Thomas Cureton, agreed that the body of a freestyle swimmer should be completely flat in order to avoid unnecessary resistance. They were wrong.

Takaishi saw through the emperor's clothes and realized that it was impossible for a swimmer to keep his or her shoulders flat. Instead, they created resistance by swaying from side to side; in particular when the swimmer was tired. Takaishi instead found that the shoulders should rotate elliptically: One shoulder is lifted while the other one drops. This movement makes the upper body roll from side to side around its own axis without altering its position. A well-executed body rotation is a terrific way of getting the center of gravity to align with the swimmer's direction in a way that wastes as little energy as possible. The position allows for a more natural way of breathing and is also optimal for the legs' position in the water. In 1995, researchers at the University of Colorado were able to show that this type of rotation also reduces frontal resistance.

However, swaying from side to side does not necessarily result in a better time. In order to enable the force from your arms and legs to move your body forward in the best way possible, while reducing the waste of force in the lateral direction, you need strong upper body muscles. The first to succeed in developing a really good body rotation was George Breen, who beat the 1,500 meters freestyle world record in Melbourne in 1956. He was the first with a time below 18 minutes at the Olympics and beat a world record that lasted for two years. Nevertheless, Breen didn't win the final, but came in fourth after a complete loss of stamina. The fact that he didn't win meant that body rotation had to wait a little bit longer for its great breakthrough – this was, in other words, a sort of bump in the road of technique development.

Your swimming: Three exercises for your upper body

#### 1. The plank

Put your weight on your elbows, which need to be located directly below your shoulders, and pull up your upper back throughout the whole exercise. Keep your feet as wide as your shoulders and

try to keep a natural arch in your lower back. Pull in and tighten your abdominals. Hold for 30 seconds, rest and repeat.

## 2. Raising your back

Lie down on your stomach with your hands against your forehead, palms facing down. Tighten your abdominals. Gently lift your upper body about 1–2 inches off the floor without arching your lower back. Hold for 10 seconds, rest and repeat 6 times.

## 3. Leg kick swimming

Butterfly kicks in particular strengthen the upper body in a way that's relevant for all types of swimming.

## THE BENEFITS OF GOOD ROTATION

### 1. Use the right muscles

The rotation allows you to use the large, strong and hardy muscles in your back and chest to move forward instead of using your small and delicate shoulder muscles.

### 2. Longer strokes

When well-executed, body rotation results in longer strokes without the strokes taking any longer to execute. Successfully using your hip helps to maintain your swimming speed, while avoiding the laborious acceleration in-between arm strokes.

### 3. Reduced resistance

The shoulder being returned to a position above the surface of the water reduces the swimmer's frontal resistance.

### 4. Relaxed recovery

The high shoulder enables a relaxed recovery instead of looking and feeling as if you're throwing a rock.

## Stroke frequency and stroke length

Body rotation changed the way the muscles worked. It used to be that only the arms and shoulders did the work. Rotation enables the swimmer to use more and larger muscles, which then generates more power and results in a higher speed. The technique elongates the arm strokes – the considerably shorter Takaishi took fewer arm strokes than the imposing Weissmuller. At the same time, Takaishi saw that there was a limit to the rotation. If the upper body rolls too much, there is a high risk of leaking energy to the sides or of slowing down in-between arm strokes.

The best method for swimming fast over a given distance is to swim with as long a stroke length and as high a tempo as possible. In theory, this sounds easy enough: Taking longer arm strokes while retaining the stroke frequency or taking more arm strokes while retaining their length. When swimmers are unable to improve their swimming, then the key is to be found in the rotation of their upper body. The level of rotation is individual, as it is very difficult to get the timing right when executing this movement without losing time or energy. It's been shown that long-distance swimmers rotate more than short-distance swimmers and also that good swimmers have a snappier rotation than slow swimmers.

## Pull acceleration

Fifty years before Westerners learned how to use this technique, Takaishi emphasized the importance of finishing the stroke quickly in order to be able to begin the new stroke.

The Japanese had started filming their swimmers underwater already in the 1930s. Researchers using locally manufactured cameras were standing with their noses pressed up against a window in the pool wall while filming their swimmers.

The Japanese period of glory extended up until the 1936 Olympics in Berlin, where Japan won the most medals. Then came the Second World War, a bump in Japanese competitive swimming that the Japanese had a hard time recovering from. At the London Olympics in 1948, Japan was not allowed not participate as they had fought alongside the Germans in the war.

## Your swimming: Four steps for swimming faster

### 1. FREQUENCY:

The best way to become a faster swimmer is by adding more swimming workouts in your exercise schedule. Until you swim six times a week, this is the most effective way of increasing your performance.

### 2. FLEXIBILITY:

Make sure that you're not held back by your shoulders. Stretching for two minutes a day will show results after a year.

### 3. SPEED:

Use a number of gears. A regular swimmer should master at least four different types of intensity: easy, easy cardio, tough cardio and sprint speed.

### 4. FINESSE:

Improve your technique. Use your upper body for synchronizing your arms and legs. The right technique exercises will get you there. Butterfly kicks strengthen your upper body in a way relevant for all types of swimming.

Philadelphia, August 14, 1976. The stands were packed at Kelly's pool in Philadelphia. It was four thirty in the afternoon and the air was as hot as in a crematorium. Ninety-one degrees and the air was trembling.

Behind the starting block for the 100 meters freestyle race was a tall and slim young man with a straight posture, pronounced chin and a dark moustache. Someone familiar with British comedy would probably detect a certain resemblance to John Cleese. The blue letters "CJAC" on his orange shirt indicated that he competed for the Central Jersey Aquatic Club. The John Cleese lookalike was in great shape. He spun his arms and looked down the 50 meter pool. The only thing on his mind was the 100 meter race ahead of him. He'd swum this race before. At least once a day for the last six months.

The gas company Philips 66 had sponsored the American swimming championships ever since 1973. Both parties were so happy with this sponsorship deal that it was to extend over a period of 40 years. The week was one long, massive celebration of the American Olympic team that had won every single medal, with the exception of one, at the men's events at the Montreal Olympics a few weeks before. Naturally, Olympic gold medalists such as John Naber, Peter Rocca, John Hencken

and Shirley Babashoff brought down a lot of applause, not to mention the women's team, which had beaten the fiercely powerful East German team in the 4 x 100 meters freestyle relay race.

At the races, however, there are two other swimmers who brought the sport back to the future: Jonty Skinner and Jesus Vassallo.

Jonty Skinner was the name of the John Cleese clone, and he was behind one of these groundbreaking achievements. He stood 6'6" tall and swam for the University of Alabama, where he'd won the American college championship in 100 meters freestyle a year prior. At this time, the men's college championships (NCAA) was the fastest swimming competition in the world. Jonty Skinner had not been permitted to participate in Montreal as he competed for South Africa. Ever since the South African Minister of Interior, Jan de Klerk, had proclaimed that its Olympic team would only consist of white athletes, South Africa had not been welcome to participate in the Olympics.

In the absence of Skinner, Jim Montgomery, who practiced in the old home pool of Mark Spitz in Indiana, had won the 100 meters freestyle in great style. He became the first swimmer to complete a 100 meter race with an average speed in excess of two meters per second. With this speed, he was able to butcher Mark Spitz' Olympic record (51.22), and his 49.99 was a whole 0.82 seconds better than Jack Babashoff, who came in second and used to practice together with Skinner in Alabama.

Skinner was thrilled standing there in the heat. He had been practicing throughout the whole summer and was in the shape of his life. As he was not allowed to compete in international championships, he had never focused on swimming fast in a 50 meter pool. When asked about his swimming, he replied: "Whatever the winning time in Montreal, I will swim faster in Philadelphia." Skinner was a pioneer in the use of mental visualization. Time and time again, he'd gone through the race in his mind. What it would feel like. What he should focus on. How he would be able to fight the shocking muscle rebellion that breaks out in a swimmer's body in the second half of a 100 meter race.

Jonty Skinner's leg kick had never been anything to write home about. Other 100 meter swimmers typically have a constantly pounding leg kick. Skinner's left foot kicked down once when his right hand entered the water, and the right foot once when his left hand did the same. In-between, he let his feet casually rotate around each other – a style he'd developed already in his young teens when practicing under his father Doug back home in Cape Town. Other swimmers who've used the same type of kick include Anders Holmertz and today's long-distance champions, Gregorio Paltrinieri and Katie Ledecky. These days, however, practically no one uses Skinner's technique for 100 meters freestyle.

The drawback of this two-stroke leg kick is that it doesn't provide all that much forward momentum. Nor is it particularly good at lifting the body; especially if you have a more muscular body. Jim Montgomery weighed 195 pounds distributed over his 6'3" frame. Jonty Skinner's slim 6'6" body weighed no more than 185 pounds and was therefore better suited for the two-stroke leg kick. A benefit of using this leg kick is that it saves a lot of energy as long as your feet and legs don't stick out too much. It may also help your balance, which is why it's beneficial if you tend to go wide when returning your arms.

Skinner's technique and mental preparation turned out to be more than sufficient for doing the race of the year. Perhaps even the decade. He crushed the Americans who'd made their way to Philadelphia. Montgomery, the Olympic hero, was not there, but Skinner nevertheless crushed his world record (49.99) and got a time of 49.44. This was also the first African world record in swimming and it was to stay undefeated until 1981.

Skinner's fierce dream race broke the norm of the dominance of the American men's team in the 1970s. The United States had won twelve out of thirteen events at the 1976 Olympics. They only lost the 200 meters breaststroke to John Hencken from the United Kingdom. At this time, participating nations were allowed to field three swimmers per event. That meant that there were 33 individual medals up for grabs. The Americans took care of 25 of these.

Another race that changed the world of swimming in Philadelphia in 1976 may be attributed to Jesus. Or "Jesse" as he referred to himself at the Mission Viejo swim club in southern California. At the 100 meters backstroke event, the heavily perspiring crowd at Kelly's saw yet another John Cleese clone walk up to the starting block. John Naber, who was also tall and wore a mustache, had won three gold and a silver medal in Montreal. His specialty was the backstroke, but he was perfectly capable of competing in the other styles as well. Jesse Vassallo was just 14 years old, had a slight frame and was a full foot shorter than the Olympic star. Vassallo was one of the most promising American long-distance swimmers after having made great times at the qualifying races for the Olympics. His 15:31 on 1,500 meters freestyle is still the best time performed by a 14-year-old. Faster than Michael Phelps himself, who's at fourth place on this list with 15:39, and Swedish Anders Holmertz, who's third with 15:37.

Just like Skinner, Vassallo had not been allowed to go to the French part of Canada to compete in the Olympics. By living in the United States, he had broken the rules of the Puerto Rican Olympic Committee stipulating that you had to live in your native country for at least one year prior to the Olympics.

On this hot day, Jesus Vassallo's second disappointing Olympics failure was still far off in the future. Following the disappointment of the Montreal Olympics, Jesse wanted to try new distances other than the monotonous long-distance races. He had finally settled on 100 meters backstroke and he'd ended up next to John Naber in the trials. The young long-distance swimmer had figured out a way of avoiding a problem that had concerned him – to more or less be drowned by the backwash from the massive Naber. After the start, Vassallo remained underwater while moving like a dolphin as he used his abdomen for moving forward. Those in the audience who weren't blinded by Naber's star-like appearance had a good laugh at Vassallo's strange style.

In the summer of 1979, the Pan-American Games were held in the Puerto Rican capital of San Juan. Puerto Rico is an island in the Caribbean belonging to the United States, but with a high degree of autonomy. When Christopher Columbus landed on the island during his second trip, he found it inhabited by Native Americans who referred to it as Borikén. The Spanish named the island San Juan Bautista in honor of John the Baptist, while the name was later changed to Puerto Rico, meaning "rich port." Puerto Rico has participated in the Olympics under its own flag ever since 1948.

Despite the fact that Vassallo had left the country when he was only eleven and that he'd also chosen to compete for the United States, he was still extremely popular in Puerto Rico. And not just there – that same year, Sports Illustrated ranked him one of the ten greatest athletes in the world together with racing champion Mario Andretti, Björn Borg and even Muhammad Ali. Ahead of the Pan-American Games, his uncle Salvador had spent 6,000 dollars on printing 2,000 bright yellow t-shirts saying VASSALLO in large, red capital letters. He handed out these t-shirts to family, friends and the rest of the audience. The people in yellow carried Jesse during the race, all the way to the top of the podium. After The Star-Spangled Banner ended, the crowd in yellow started singing the Puerto Rican national anthem La Borinquena. The excitement of the crowd knew no bounds when Jesse pulled up a Puerto Rican flag. Jesus "Jesse" Vassallo, the son of Puerto Rico who was just 17 years old, was the best swimmer in the world.

As expected, the 14 year old Vassallo was unsuccessful in the 400 meters medley. Nevertheless, he was still no more than two seconds away from qualifying to the American team. When he won the

same Olympic qualifying race four years later, his time was 4:21. At the 1980 Olympics in Moscow, which President Jimmy Carter chose to boycott as a result of the Soviet invasion of Afghanistan, Olexandr Sydorenko won the 400 meters medley with a time of 4:22.

The Olympic swimming events in Moscow were limited to say the least. At the 1976 Olympics in Montreal, 262 men and 208 women from 51 countries had participated. In Moscow, there were only 190 men and 143 women from 41 countries. Not only the United States was missing among the nations that had won medals in 1976, but also West Germany, Japan and Canada. Nor did the strong Italian team participate, whereas the British protest was of a more typically British and polite variety, where the nation sent a team that was smaller than would otherwise have been the case. France and the Netherlands participated without their flags being displayed on the state-run Soviet television. Somalia, Gabon and Norway also boycotted the games, but this did not affect the outcome of the events.

So, what about Puerto Rico? Well, German Rieckehoff, head of the island's athletic federation, wanted to send a team based on his conviction that sports and politics shouldn't be mixed. He didn't receive any financial support from the government, but was still able to send the boxer Alberto Mercado, who subsequently became the only American citizen to participate in the 1980 Summer Olympics.

Irvine, California, July 31, 1980. Glenn Mills was 18 years old, but he was just as tired as a sanatorium patient. During the past year, he'd been drilled by his young and ambitious coach, Dennis Pursley, in accordance with the Nietzsche philosophy of "what doesn't kill you, makes you stronger." Twice a day, he and the other swimmers of the Cincinnati Pepsi Marlins swam 10,000 meters. Six days a week. As Mills' specialty was the breaststroke, he used this style for swimming 30 percent of this distance. Breaststroke is the slowest swimming style. Some days, he swam 20 x 400 meters breaststroke with six minutes of rest in-between sets. He was able to do the final 400 meter set in 5:10, which still to this day is a respectable time given the extreme amount of exercise. Mills and his best buddy, Greg Rhodenbaugh, swam in silence. Just like the rest of this group ruled by a friendly but firm hand. During the school year, the morning workouts started at five o'clock in the morning. After having completed 10,000 meters in the pool, they did sit-ups and other exercises on land before having a hearty two-three dollar breakfast and going to class. Following the afternoon workouts, they practiced starts and turns. Instead of going to church on Sundays, Glenn Mills stayed in bed like a mummy. The only time he got up was to go to the fridge to get something to eat.

During the last two weeks before the major competition of the summer, the US championships, they had swum a little bit less – "only" 6,000 meters a day. Yet Mills walked around yawning and feeling even more tired than before. Coach Dennis assured him that he would soon feel better, but nothing happened. As could be expected, the 100 meters breaststroke was a disaster. He'd hoped for a medal, but only managed to do 1:05.24 and thus missed the final.

The next day, the club's wonder child, Mary T. Meagher, won the 200 meters butterfly with an astounding five seconds before the person coming in second. Her 2:06.37 was over four seconds faster than Ines Deissler's gold medal race at the Moscow Olympics just a few days before. Mary's record race inspired Mills, and he decided to break down and give it another go. The 100 meters breaststroke was not his best event. It requires more speed during the first length, which wasn't exactly what he'd practiced during his daily marathon sets.

In the 200 meters breaststroke trials, Glenn Mills came in second after John Moffet, who was also in his teens but from California. At least the race ignited a sense of hope in Mills. However, he was still tired at the start of the final that same evening. In spite of all the times he and his buddy Greg had practiced starts following the evening workouts, water now seeped into his glasses. His arms and legs were more than just a little worn out. It felt as if he'd jumped into a pool of turquoise paint instead of a pool of water.

In breaststroke, most of the power comes from the leg strokes. Mills noticed that his swimming was not as fierce and energetic as when he'd been swimming as best he could. At 100 meters, he was the last in the field – over than two seconds behind leading Nick Navid from the Texas Longhorns.

If we stop for a moment, cognitive psychologists believe that there are three ways of managing obstacles: 1) What happened is predetermined and impossible to alter. Besides, learning how to cope with suffering is beneficial. This is God's Way. 2) It's someone else's fault: coach Dennis or whoever made the glasses. This is Your Way – an approach that ultimately makes you bitter. 3) You take the helm and make the best out of the situation. The sum of your choices leads to a positive outcome through an "every little bit helps"-effect. This is My Way.

At the age of eighteen, Glenn Mills had not read any self-help books. He had barely read any books whatsoever. The tough exercise program meant that he didn't study more than necessary. He memorized the American Constitution, the most important presidents and learned basic grammar and mathematics that was sufficient for figuring out if he received the right change when buying breakfast.

Furthermore, Mills had not been able to muster enough energy to go to church, which excluded option one above. Suffering was something he'd done during practice. He had put so much pressure on himself that his vision had turned all blurry. He'd gotten up at a quarter to four, six days a week, and he'd swum with cramps, sunburn and with glasses that were way too tight. Yet there was nothing as painful as a bad race. Nor was there any time to suffer. Furthermore, coach Dennis had impressed upon his swimmers that they were not allowed to blame anyone else for their failures. At least not the coach. Then Mary T. Meagher performed beautifully at the 200 meters butterfly event.

Glenn Mills now started working his way up the field. 1:08.8 was not a particularly good time for the initial 100 meters. In the stands, coach Dennis did not believe that he could get a time below 2:20. John Moffet in the lead was swimming toward what looked like a safe victory. Mills knew that he still had some power left in him and after the last turn, he gave everything. He was the only one in the field able to step up his pace and it looked as if he was about to come in second in the race and get a spot on the American team, which would obviously not be allowed to go to the Olympics, but would nevertheless be recognized in a ceremony by the swimming association. This was not what was on Mills' mind at the moment – he just swam for all he was worth. He swam so hard that he was able to catch up with Moffet, who was not yet entirely wasted, but nevertheless failed to counteract Mills' spurt of energy. At the end, it looked as if they both touched the pool wall at the same time, but the electronics of the time indicated that Glenn Mills had won the race with a measly one hundredth of a second.

Qualifying to be a part of an Olympic team without any Olympics to compete in was obviously frustrating. At the same time, both Moffet and Mills were still young with a great future ahead of them. The obvious career objective, the 1984 Olympics in Los Angeles, was still far off in the future. Glenn Mills spent these four seasons at the University of Alabama, and John Moffet, who was only 16 years old in 1980, ended up in Stanford a few years later.

John Moffet made it to the 1984 Olympics back home in Los Angeles as the world's greatest breaststroke swimmer after having set a new 100 meter world record and having won the American Olympic qualifying races. In Los Angeles, he hoped for a gold medal, but unfortunately he tore a thigh muscle during the trials. Nonetheless, while in great pain he made it to the final with a bandage wrapped tightly around his leg. Without any real chance of winning, Moffet managed an easily forgotten fifth place. He left the Olympics with a feeling similar to that of

failing your driving test, which is more uncommon than being struck by lightning in the United States.

Glenn Mills performed a lousy 200 meters breaststroke race at the American qualifying races. He placed fourth, more than a second slower than four years before, and was unable to join the team. The Olympics is the greatest thing that can happen in a swimmer's career and something that opens doors in an America that loves winners. Mills couldn't help going through his career over and over in his head. What if Jimmy Carter hadn't mixed politics and sport? The Olympics being cancelled during the two world wars was one thing, but this was nothing but political drama.

Let us return to cognitive psychology. Fortunately, it was not in Mills' nature to dwell on things he was unable to control. At the age of fifteen, he'd lost his beloved older brother to cancer; something that put his competitions in perspective. Instead of being bitter, he was grateful for his career and for all of the possibilities, experiences and friends it had brought him. Today, Glenn Mills works as a swimming consultant helping young swimmers understand how good they can become by improving their technique and physical status. In what's a pretty odd coincidence, coach Dennis Pursley is now the head coach for the swimming team of Mills' old college in Alabama.

Your swimming: How to do the breaststroke

1. **THE LEGS.** Your legs are what brings you forward. Rebecca Soni, female swimmer of the year in 2011, was measured as having a forward driving force to the tune of 100 newtons in her legs compared to 20 newtons in her arms. Even though not all of us have her leg power, this nevertheless gives you an indication of just how crucial the leg kick is when doing the breaststroke.
2. **THE ARMS.** Don't let your arm strokes be larger than they need to be. Anyone overestimating the importance of arm strokes also tends to let his or her arm strokes be too large. Your elbows need to go in before your chest in order to ensure that you're not too wide when the leg kick moves you forward.
3. **FIND YOUR STYLE.** A few good breaststroke swimmers, such as Adam Peaty and Ruta Meilutyte, use fast, powerful arm strokes. Others slide more like Megan Quann. You may also move your hands above the water in the same way as Rebecca Soni.
4. **THE HEAD.** Look down into the water in front of you as you breathe; in other words, don't look up too high.

Someone who, in 1984, was finally able to compete in the Olympics was Jesse Vassallo. He had moved back to Florida, where he swam for the college team the Miami Hurricanes. The previous teenage star was fast, but not fast enough for winning a medal in 400 meters medley. He had shared the second place in butterfly, but then fallen back during the breaststroke to end up about a second short of the bronze medal.

Jesse Vassallo did not compete at the 1988 Olympics in Seoul, where the family honor was instead defended by his youngest brother, Sal, who unfortunately didn't succeed in making it to the final. What's more interesting from a perspective of swimming science is how his older brother Jesse's idea from the backstroke final in Philadelphia 1976 had by now started to influence others.

Someone else competing in Seoul was backstroke swimmer David Berkoff, who'd been a good junior swimmer, however far from being a star. Three years before the Olympics, Berkoff decided to try to swim underwater. By using dolphin-like movements, he was able to swim longer and longer distances underwater while maintaining his speed.

## WHY IS UNDERWATER SWIMMING FASTER?

Swimming science used to claim that:

- Swimmers can't move forward as quickly by using their legs as compared to using their arms.
- The energy consumption involved in a leg stroke is higher compared to an arm stroke, as the legs are larger and thus require more oxygen.

The first claim was based on freestyle swimming, where it is still valid, whereas the second claim is still true.

A good way of taking a field science forward is by learning from other fields. When a butterfly swimmer swims according to the traditional style, he or she has a leg kick frequency of 44–56 kicks per minute. It's difficult to increase this frequency, as swimmers are limited by their ability to increase their arm stroke frequency.

Already in 1957, Richard Bainbridge at the Cambridge Zoological Laboratory was able to show the swimming speed of fish increased in proportion to what he referred to as the "tail beat frequency," which corresponds to the leg kick frequency of a butterfly swimmer. So, what David Berkoff had practiced had already been studied thirty years prior by Bainbridge with regard to fish like dace and trout.

Berkoff used the butterfly kick, but by being positioned on his back, he was able to perform 120–180 kicks per minute. By shaping his arms into a spear, or the head of a fish for that matter, he was able to swim more like a fish than anyone had ever done before.

By using the new technique in the qualifying race for the Olympics, Berkoff was able to beat the world record held by Russian swimmer Igor Polianski. And at the trials in the Seoul Olympics, he was even faster. 54.51 was incredibly fast, but the most revolutionary thing was the way he did it. The Japanese swimmer Daichi Suzuki, who'd started to kick his way underwater already in 1984, had slipped under the radar and had made it to the 100 meters backstroke final, where he and Igor Polianski now flanked Berkoff. Suzuki used to swim 25 meters underwater, but now decided to swim an additional five or six meters. Berkoff swam almost the entire first length underwater and made a lightning fast turn. However, swimming for such a long distance without breathing results in an oxygen debt and muscle fatigue, so Berkoff lost all momentum during the last few meters, enabling Suzuki to catch up and win the first Japanese Olympic gold medal in twelve years. Following the final, the International Swimming Federation (FINA) felt a need to act and immediately decided to limit underwater swimming by, among other things, arguing that butterfly and backstroke swimming had become increasingly similar. The limit for underwater swimming was set to 10 meters, which changed the life of underwater swimmers such as Berkoff and Suzuki. A few years later, FINA redefined the limit to 15 meters, which since 1998 applies to both backstroke and freestyle swimming.

Your swimming: Tips for developing your underwater technique

### 1. Posture

Kicking is not about generating speed. It's about maintaining the high speed you get by pushing away from the starting block or the side of the pool. A good kick is dependent on low resistance and a forward-going posture.

## 2. Flexibility

Having flexible shoulders makes you pointier, thus enabling you to cut through the water like a sword fish. Flexible hips and ankles result in more power from your kick.

## 3. Fins

The best aid for getting a good underwater kick is using fins. They give you a good return on investment when used correctly. Diving fins are too long and make you perform your kicks with your knees bent. The kick should instead come from the hip. A serious kicker has three pairs of fins. A pair of standard-sized fins, preferably with an open heel. A pair of smaller fins for a faster, more swim-like kick and a large blade monofin, which requires a stronger swimmer.

## 4. Tempo

The higher the frequency of your kicks, the faster you swim. This naturally implies that each kick is equally good. Generally speaking, you want to make small and fast kicks.

## 5. Strength

Your upper body must be able to provide tempo and maintain your good posture. Your thigh muscles need to be in sync with your upper body. The power of the kick is meant to go both up and down. It's common that the upward kick lacks power and speed. The speed of your toes at the end of the kick is important – think of your upper body as the handle on a whip and of the tip of your toe as the end of this whip.

## SCIENCE HELPS SWIMMING GOING FORWARD

Takaishi, Skinner and Vassallo have all been important for swimming and they represent three great examples of a sport where the format of the competition alters the conditions. They've been the tide that lifted the boats.

Through history, it's been more the rule rather than the exception that the most successful swimmers have had to put up with watching their competitors trying to imitate their styles. And this regardless of the abilities and makeup of their competitors.

At the beginning of the 1990s, Matt Biondi and Alexander Popov dominated 100 meters freestyle – the event in swimming that gets the most attention. They were both 6'7" and used a body rotation style when swimming. They both took very long arm strokes and didn't have the same high frequency as previous swimming stars. Furthermore, both Popov and Biondi looked like models, so there's no surprise that every teenager wanted to swim the way they did. A former world record holder in 100 meters freestyle, Rowdy Gaines, carefully tried to introduce an alternative way of thinking in the magazine *Swimming Technique*: "Not everyone should use long arm strokes. Not everyone can be Popov." Simple mathematics says that if a taller swimmer's arm strokes are as frequent as those of a shorter swimmer, then the taller swimmer has a brilliant opportunity of maintaining a higher speed by taking longer arm strokes.

Almost 90 years after Katsuo Takaishi's performance in Amsterdam, it has now been demonstrated that both shorter and taller swimmers may increase their speed by rotating their bodies. Even though Takaishi's observations were correct and even though his principles are used by every current elite swimmer, there is no Nobel Prize in swimming, which why his deeds are largely forgotten. The saying "Tell the truth too early and your words will be ignored. Tell the truth too

late and everyone will be bored” has repeatedly turned out to be correct during the course of the history of swimming.

## EIGHT INNOVATIONS THAT HAVE IMPROVED THE SPORT OF SWIMMING

### 1. Body rotation

Under Katsuo Takaishi, the Japanese started using this method in the 1930s. It was improved upon by George Breen in the 1960s. It's one of the basic aspects in Total Immersion, Terry Laughlin's commercial packaging of freestyle swimming for regular people in the 1990s.

### 2. Flip turn

The American swimmer Al Vande Weghe made the first flip turn in 1934. However, for many years after that, swimmers were forced to touch the wall with their hand before turning, which to a large extent offset the effect of this innovation. Don Schollander won the 400 meters freestyle event at the 1964 Olympics without using flip turns. Since then, flip turns have become the norm.

### 3. Bodyskin

Men wore swimming trunks for the first time in 1935. Until then, they used to wear swimsuits. From the minimal swimming fashion of the 1980s, the swimsuit was relaunched at the end of the 1990s, also for men. This trend culminated in 2009 with full bodysuits made out of rubber. Swimsuits with floating properties were banned in 2010.

### 4. Underwater kicks

Jack Sieg developed breaststroke kicks in 1935. They were subsequently banned to then be reborn as part of the new swim style known as butterfly swimming. Jesus Vassallo took kicks underwater in 1976, and David Berkoff and Daichi Suzuki started using them for swimming really fast in 1988.

### 5. Shaving

At the Melbourne Olympics in 1956, the Australian swimmers Jon Henricks and Murray Rose shaved their bodies – and won gold medals. Shaving reduces friction between the body and the water. It also gives the swimmer a better sense of the water, which results in a better execution of the required movements.

### 6. Swimming glasses

Persian pearl divers used polished tortoise shell to protect their eyes already in the fourteenth century and Thomas Burgess used swimming glasses when he swam across the English Channel in 1911. In the 1960s, swimming glasses contributed to swimmers being able to withstand increasingly longer workouts in pools with high levels of chlorine. Swimming glasses were first permitted at the Olympics in 1976.

### 7. Track start

When Mark Spitz ruled the 1972 Olympics, he was one of only a few swimmers holding on to the starting block with his hands. The other swimmers spun their arms around the body to then throw themselves into the water in a flat dive. After 1972, more and more swimmers tried to start like Spitz and sort of dive into a small hole. At the 1998 World Championships in Perth, swimmers started putting one foot in front of the other, just like in track and field. Since then, the starting blocks have been given a surface with more friction, they've been made taller and also have a steeper slope in order to fit this so-called track start.

### 8. Weight training

Up until the 1950s, it was believed that all forms of weight training were out of the question, as it made swimmers less flexible and resulted in them sinking deeper into the water. These days, however, every elite swimmer uses some form of weight training.