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An application of science, technology is producing profound and increasingly rapid changes to our society and the way we live. The Athletes and Science exhibition explores the influence of technological innovations on top-level sport: how do they improve athletes’ training and performances? How do they contribute to record-breaking feats?

Divided into four parts, the exhibition focuses firstly on athletes, who benefit from the advances made in physiology (study of the body, its capacities and limitations), sophisticated training equipment and new materials that help to optimise their equipment. It then highlights how technological progress affects coaches, whose work is becoming more objective thanks to visualisation and statistical analysis tools. In addition, judges are able to use more accurate measuring devices and spectators can enjoy image processing software that gives them spectacular detail and comparisons.

*Athletes and Science* examines numerous scientific fields in a very practical way. It presents the basic scientific principles as well as how they are applied in sport. Through these examples, it is our *relationship with technology* that is put under the microscope: the notion that technology can achieve anything and the fear that the growing influence of technology will ultimately make the role of human beings a secondary one. The exhibition also tackles the issue of the *relativity of records* set in different eras using incomparable technological equipment.

The exhibition only considers legal methods: the *question of doping* is therefore not directly examined (a section of the permanent exhibition is devoted to this subject).

**WHY VISIT THIS EXHIBITION WITH YOUR PUPILS?**

*Athletes and Science* enables teachers to tackle scientific questions in a practical and relevant way, and to discuss the influence of technology in a sphere that forms part of pupils’ everyday lives: that of sport. As spectators of top-level sport and/or amateur athletes themselves, pupils will be able to:

- Discover how science and technology improve sports performances (*History, Sport*).
- Study and understand underlying mechanisms (*Science*).
- Analyse from a distance how science and technology change the practice of sport (*Social studies*).
- Consider the relationship between human beings (athletes) and the technology that surrounds them (*Social studies*).
- Contribute to these discussions with reference to their own experiences (*Social studies*).

It is important to prepare for the visit in the classroom in order to encourage pupils to consider certain questions about the links between science and sport. In this way, they can think about their own expectations and visit the exhibition in an active, inquisitive frame of mind.
EDUCATIONAL KIT

The first part of the kit proposes a *step-by-step visit* to the exhibition. This visit is not exhaustive and focuses on a number of themes and hands-on activities\(^1\) to be carried out in situ. A series of questions\(^2\) is suggested to help teachers encourage dialogue with their pupils during the visit and provide appropriate supervision.

The general aim of this visit is to make the innovations presented in the exhibition relevant to the pupils’ everyday lives. Do they use a similar video system? Have they ever conducted reaction tests? Have they recently changed equipment in order to benefit from technological advances?

Another common theme is the link that can be established between the different areas in which technologies are used. A technology that can aid training not only improves athletes’ performances, but can also be used for statistical purposes by coaches. Techniques for the visualisation of athletes’ movements help not just the athletes themselves, but also help judges to award marks and make events more spectacular. It is therefore easy to see how a technology devised for one field often ends up benefiting a broader group of users.

The second part of the kit looks at three technological innovations in greater detail. It complements the visit to the exhibition\(^3\) and facilitates in-depth discussion in the classroom. It covers all aspects of these innovations, explaining how they work, their history and their influence on competitive sport and everyday life. For each innovation, a series of related discussion topics\(^4\) are suggested.

\(^1\) Hands-on activity to be carried out at the exhibition
\(^2\) Suggested questions
\(^3\) Exhibition recall
\(^4\) Discussion topics
LEVEL +1

The visit begins on floor +1, which is entirely devoted to athletes.

1.1 ATHLETE – APTITUDES
- ANTHROPOMETRIC FACTORS
- METABOLIC FACTORS
- SPRING AND BALANCE
- VISUAL ACUITY

1.2 ATHLETE – PERFORMANCES
- SPORTS EQUIPMENT AND MATERIALS
- NEW TRAINING TOOLS

The first section focuses on the measurement of athletes’ physical aptitudes, while the second looks at performance and training.
Scientists have always been interested in the human body and its physical aptitudes. Morphologists, for example, study the external form and the structure of living beings. Every sport requires particular aptitudes. New measuring techniques facilitate the analysis of athletes' bodies and the prediction of young athletes’ future development.

**ANTHROPOMETRIC FACTORS**

It’s better to be tall if you want to play basketball. A swimmer will float better if he has a bit of body fat. However, it remains difficult to identify what the “ideal” body would look like for each sport because performances also depend on technique, tactics and, where team sports are concerned, a wise combination of different talents.

1. Measure your height and weight, and compare your morphology with that of champions in various sports.

2. Estimate your body fat percentage (see glossary, p. 21) using the bioimpedance scales.

   The scales estimate the quantity of water present in the body and, hence, the quantity of fat. They work by sending a very weak electrical current through both feet. It will pass less easily through fat than through water, since water contains electrolytes, which are salts with a high conduction rate. The method is not very reliable because it concentrates on the bottom part of the body and also depends on temperature, stress and fatigue. It is important to learn to be careful with this type of data, which is often only useful as part of a global analysis.

3. Measure your spring from a standing position: the distance between the ground and the soles of your shoes, without a run-up.

   Here, you can measure your jumping ability, which is essential in basketball and volleyball. Surprisingly, the world record (152cm) is held by French basketball player Kadour Ziani, who is only 1.79m tall. Note the simplicity of this measuring system: hi-tech methods are not always necessary.

**METABOLIC FACTORS**

Morphology is not everything. Aptitudes (oxygenation, reflexes, etc.) can be improved through training.

4. Show pupils the altitude chamber and explain how it works (the test takes too long for a whole class). It illustrates how a lack of oxygen makes physical effort more difficult. A positive effect would only be obtained after a stay of several days.

   Muscles need oxygen in order to function, which is why people breathe more heavily during sport. Above 2,000m, the lack of oxygen makes physical effort difficult, but after a period of acclimatisation, the body begins to produce more red corpuscles, which transport oxygen all over the body. Since these extra corpuscles remain in the body for weeks, an athlete who returns to normal altitude will be able to oxygenate his muscles more easily and therefore perform better.

   Altitude (or hypoxic, meaning “low in oxygen”) chambers simulate this lack of oxygen at normal altitudes, making it unnecessary for athletes to train at high altitude. The IOC has concluded that this technique does not affect athletes’ health and does not constitute a form of doping. The issue remains complex because a very high red corpuscle count could actually be dangerous. Moreover, the use of the doping product EPO (which achieves the same result by stimulating the production of red corpuscles) is banned.

What morphological characteristics can you name?

Height, weight, body mass index (weight/height*height), muscle mass, body fat percentage, muscle distribution, length of arms and legs, size of hands and feet, waist measurement, etc...

How important are they for the practice of a sport?

What are the different types of fatigue?

In sport, we are limited by our muscles, pain or respiration (shortness of breath).

Should doping be defined according to the method or the result?

(see also “The cryotherapy chamber”, p. 18)
SPRING AND BALANCE

Spring is a movement that involves the extension of the muscles. It depends on muscular power. A “powerful” movement is a combination of high levels of speed and force. In physics, power is defined as the product of force and velocity. It is an explosive movement, such as that of a weightlifter quickly lifting his weight. However, other sports require so-called “low velocity” power, such as a skier who remains in position in order to gain speed (this may appear paradoxical...).

Test your spring and balance.

This test combines explosive power (jumping as high as possible) with the need for balance (becoming stable as quickly as possible after each jump). It illustrates how technology can produce new types of training and could even, in principle, result in the invention of new sports.

The device contains an accelerometer, which measures changes of speed. It can therefore calculate the trajectory of a jump and the height reached (this problem can be solved in a physics lesson). It can also measure the time required to regain balance, i.e. acceleration close to zero.

VISUAL ACUITY

Visual acuity (the eye’s ability to distinguish between two points very close together) cannot really be improved through training. However, it is possible to wear contact lenses or undergo laser surgery (like golfer Tiger Woods) in order not just to correct visual impairments, but also, in some cases, to achieve better than normal vision. Perception, on the other hand, can be improved through training.

Test your visual perception of a ball.
In order to win competitions, athletes need to improve not only their aptitudes, but in particular their performances. Technology helps them to train and measure their progress. It provides numerous innovations in terms of equipment, physical preparation and the quest for optimal movements.

SPORTS EQUIPMENT AND MATERIALS

In order to help a skier not to be too shaky or a swimmer to float well, new materials are developed, analysed and improved in laboratories.

→ see also «Polyurethane swimsuits», p.14

Test the differences between the absorption and buoyancy of different objects.

Cushioning: examples of surfaces.

Buoyancy: examples of objects.

NEW TRAINING TOOLS

Finding the ideal sail.
Real-time imaging technologies developed at the EPFL help sailors to find the ideal shape for their sails.

Memory training...
Memory plays an important role, especially in sports that follow a particular course.

... and coordination training.
Coordination of movement and speed of execution and reaction are crucial in many disciplines: combat and ball sports, driving, etc. Machines can now be used to test and improve reflexes.

Test your reflexes using a device used in Formula 1. Drivers like Fernando Alonso and Heikki Kovalainen have achieved 138 touches per minute, but an amateur holds the record (152).
LEVEL +0

This floor is devoted to coaches, judges and spectators.

1.3 COACHES
- POSITION OF THE ATHLETE’S
- PHYSIOLOGICAL MONITORING OF PLAYERS
- SIMULCAM AND STROMOTION

1.4 JUDGES
- ATHLETICS 100M
- STARTING BLOCK AND TOUCH PAD

1.5 SPECTATORS
Technology has also significantly changed the work of coaches, which has become less intuitive. It now relies on objective figures and statistics provided by computer tools using sensors, cameras and training devices such as those exhibited in the last room visited. Coaches can now therefore monitor a player’s progress in training and their performances during competition.

Coaches nowadays are surrounded by specialists with expert knowledge: equipment specialists, fitness coaches, physiotherapists, sports doctors and psychologists, who try to ensure that athletes are in the best possible mental state. For victories are also won in the head.

POSITIONING OF PLAYERS

Using cameras, a computer can monitor every team member and produce statistics about their movements. Coaches can therefore see how far their players have run, monitor their sprints, analyse sequences of play and check whether their strategies have been properly implemented.

Test a movement analysis system.

PHYSIOLOGICAL MONITORING OF PLAYERS

Joggers are already familiar with this device: a watch that measures their pulse. More sophisticated versions transmit data wirelessly. Coaches can then monitor athletes’ heart rate in real time and see if there is any scope for pushing them a bit further.

SIMULCAM AND STROMOTION

▶ See «Image processing: from spectators to coaches», p.16

1.4 JUDGES

Technology has become necessary for judges to separate sprinters, detect false starts or even see if a ball is “in” or “out” (“hawk-eye” system in tennis). It acts as the judge’s “third” eye.

Many sports (basketball, hockey, baseball, rugby) accept the use of video technology during (to help the referee take decisions) or after a match (to punish players guilty of serious offences). One exception remains football, where blatant refereeing errors (such as the famous unpunished handballs of Diego Maradona and Thierry Henry) have appalled numerous fans.
ATHLETICS – 100M

Start...
Anticipation is banned in sprinting. A false start is called if a runner begins to rush out of the starting blocks during the first 100ms (millisecond) following the starting pistol. Studies have shown that a shorter reaction time (see glossary, p.21) is virtually impossible. It would suggest, therefore, that the sprinter tried his luck by anticipating the gun. In order to measure this start time, a device detects the moment when the sprinter begins to push against the starting block.

Sprinters have excellent reaction times: Usain Bolt started in Beijing in 165ms, whereas Mr or Mrs Average would take 235ms. In fact, an athlete can lose a race even if they run the fastest: even though he was the quickest over the 100m, Carl Lewis finished second behind Leroy Burell in New York in 1991 because he started 49ms later.

Furthermore, the sound of the pistol is transmitted through loudspeakers placed behind each sprinter. Otherwise, the runners near the gun would have a slight advantage due to the greater volume of the sound, which favours a rapid reaction.

2 Start a 100m race and test your reaction time.

... and finish
The position of the athlete’s chest determines the end of a race. When the runners finish neck and neck, a photo finish is used to establish the winner.

3 A photo finish is taken at the end of the race.

STARTING BLOCK AND TOUCH PAD

In swimming, the finish is marked by the swimmer pressing on a touch pad. At the Beijing Olympic Games in 2008, the 100m butterfly final between Phelps and Cavic was won by 1/100 of a second. Analysis of vertical images of the finish confirmed the result indicated by the touch pads.

4 Simulate a swimming race, from the starting block to the touch pad at the finish. You have to apply the necessary force (equivalent to 3kg) in order to activate the touch pad. If the touch pad were too sensitive, it might be triggered by a wave.

A photomontage shows 100m world records from various eras. What has contributed to this progress?

• training methods;
• medical knowledge;
• equipment (track surface, shoes, starting blocks).

These records cannot be used to compare the athletes themselves. They represent the best performance achieved in a given era.

How do you expect to watch the Olympic Games in 50 years’ time?
More interactivity, choice of viewing angles, statistics. Encouragement of players from your living room via microphones?

In order to make televised sport easier to understand, TV viewers (and sports commentators) benefit from the same visualisation tools as coaches.

The history of Olympic Games broadcasting methods perfectly illustrates the development of our society as it enters the era of global, instantaneous information.

Video games, which today represent a larger market than cinema, have always offered virtual sports competitions. The level of realism has become exceptional. Aided by recording and movement analysis technologies, this virtual world is now populated by realistic replicas of real players.
The final section of the exhibition provides an opportunity to summarise the main points of the visit and to return to some of the points raised in the introduction (see p.2). Pupils can therefore quickly go back over the exhibition and remember it better.

It is a good idea to step back a little from all these technological innovations. Of course, this torrent of information helps to give greater objectivity, but it takes a long time to analyse it all.

**SCIENTEKCITY**

The “ScienTekCity” section enables pupils to start thinking about the future of sport, an exercise to be continued in the classroom (see “Suggestions for further study”, p.20).

**NOTHING REPLACES THE ATHLETES**

Technology is fascinating, but should not overshadow human beings. Athletes often remain the driving force behind revolutionary advances, such as the Fosbury flop, invented by Dick Fosbury.

**REFLECTING ON THE EXHIBITION**

Think about one of the innovations presented and observe how it affects the different stakeholders (athletes, coaches, judges and spectators).

Devices used to measure physical performance are useful for athletes, but also help coaches to plan their sessions and to monitor athletes’ progress. They can also assist judges (false starts in sprints based on reaction times) and make the spectacle more exciting (hawk-eye in tennis).

Visualisation tools (such as the StroMotion imaging technique) developed initially for television are also used by judges in figure skating.

What other stakeholders (apart from athletes, coaches, judges and spectators) are involved in sport?

Media, investors, politicians (cashing in for electoral purposes, patriotism), athletes’ families, fans.

What do many of the innovations presented in the exhibition have in common?

A lot of electronics and figures. Anything that can be measured these days is “digitised”: the measured signal is converted into digital data that can be processed by computer. It can then be transmitted wirelessly, represented graphically and used to produce statistics. These developments in sport reflect those in our society, where intuition is increasingly being replaced by rational figures.

Growing importance of images and visualisation tools.
This part of the kit examines in greater depth three technological innovations and their impact on high-level sport. It explains how they work and suggests topics that might be discussed with pupils in the classroom after the visit. Based on these three innovations, group research projects may also be suggested to pupils.

**POLYURETHANE SWIMSUITS** raise the question of the difference between high-level and amateur sport. Competitive sport is often the catalyst for inventions that will benefit the general public decades later. But how does a hi-tech swimming costume really benefit an amateur? Is it acceptable to improve your performance without physical effort? This part offers a succinct scientific analysis of swimming and explains how these swimsuits improve swimmers’ performances.

The section on «IMAGE PROCESSING: FROM SPECTATORS TO COACHES» looks at new ways of presenting images. It creates a link with the everyday lives of pupils, who are familiar with these new visual techniques, present in video games and some smartphones. It also illustrates how a young company in the field of advanced technologies develops its markets and ends up benefiting TV viewers as well as athletes and coaches.

**CRYOTHERAPY CHAMBERS** illustrate the sometimes extreme methods used to optimise an athlete’s physical performances. At first glance, exposing the body to a temperature of -110°C in order to train better seems like something out of science fiction. But for an athlete who is constantly working on his body, any hope of improvement is to be taken seriously. The body becomes a machine that needs to be maintained, oiled, even frozen... How far will they go? This third innovation is not exhibited in Athletes and Science. It paves the way for further study (see «Suggestions for further study», p.20), of the future of sport.
2.1 POLYURETHANE SWIMSUITS

108 swimming world records broken in 2008 (including 21 in the 32 events at the Olympic Games in Beijing)... That year, 11 swimmers completed the 100m in under 48 seconds, whereas only one swimmer had managed it between 2000 and 2007. Why? The introduction of hi-tech polyurethane swimsuits.

This spectacular improvement in performance triggered huge controversy, especially at the Swimming World Championships in Rome in 2009. Since 2010, completely waterproof swimsuits have been banned by the International Swimming Federation (FINA). Swimmers must wear costumes made of permeable fabric.

The advantages created by these swimsuits are undeniable and raise the question of comparisons between records. How can the performances of athletes from different eras be compared if they used different equipment?

Looking back in time
Compare the swimming costumes worn in 1924 (Johnny Weissmüller), 1984 (Alexander Baumann) and 2009 (Alain Bernard). What do you notice?

Swimsuits are becoming long again, like in the early 20th century, when they covered more of the body for reasons of decency rather than performance.

THE SCIENCE OF SWIMMING
Water slows swimmers down in several ways.

- The shape of the swimmer while swimming is essential. It is necessary to ensure that as little body surface as possible resists movement by adopting an elongated position in order to cut through the water hydrodynamically (think of the position skiers adopt when trying to accelerate). A tall swimmer with broad shoulders and narrow hips offers less resistance to forward movement [reminiscent of the shape of a drop of water falling, offering least resistance to the air]. It is also important to minimise the backwash [or turbulence] created behind the swimmer.

- The waves created by swimmers generate high-pressure zones that they have to cross and which slow them down. New swimming pools are equipped with wave-breaking lines designed to ensure that swimmers near the edge, where the waves are naturally stronger, are not disadvantaged. It would be beneficial to swim underwater (where there are no waves) – but that is forbidden!

- The friction between the water and the swimmer’s body and swimsuit slows them down. Swimmers shave their bodies in order to reduce it.
THE SECRET OF HI-TECH SWIMSUITS

- **They are elastic.** They act like girdles, compressing the muscles, thus reducing resistance to the water.
- **They are highly waterproof,** trapping air bubbles and therefore increasing the swimmer’s buoyancy. Resistance to the water is lower because less of the swimmer’s body is submerged.
- **Their surface is smooth** with low friction coefficients. They are also treated with hydrophobic products which help the water to flow over the swimsuit.
- **The seams and zip are carefully designed** to offer the least resistance possible.
- **The swimsuits are made of polyurethane,** a plastic which gives elasticity and watertightness. This polymer (a mixture of macromolecules) can take numerous forms (rigid foams, hard or flexible plastics, synthetic fabrics, etc.).

DISCUSSION TOPICS

Where should the limit be set for innovative accessories?

Should swimmers swim naked? Not necessarily: the FINA rules are clear and now forbid any swimsuit or device that improves the swimmer’s speed, buoyancy or endurance. It should be noted that all sports use accessories (skis, poles, racquets, shoes) that clearly must – and can – be regulated. However, technological progress is so rapid that it is sometimes difficult to anticipate and adapt the rules before they are used in competition. Should “moratoria” therefore be introduced, i.e. temporary bans pending the results of all the necessary tests?

How useful are they for amateurs?

Competitive sport has often led to innovations that prove useful for amateur athletes, especially in terms of comfort and safety. The polyurethane swimsuit is mainly designed to improve performance. Is it worth for an amateur to buy one for a high price (CHF 450)? In any case, most amateurs lack the technique that would enable them to derive any benefit from it.

Hydrodynamics

Drop various objects into a glass of water and analyse why they fall at different speeds. Their volume affects buoyant force, their shape changes resistance and their surface determines friction. The same experiment can be conducted in air, where the buoyant force is usually negligible. Compare the fall of a sheet of paper screwed up into a tiny ball with that of a looser ball, or the shape of a falling droplet of water. Study the relationship between different shapes (cube, sphere, droplet) and their coefficients of friction [see glossary, p.21].

What technological advances produced by competitive sport may be useful for amateurs, and which are useless?

- (Useful) skis that absorb vibrations, lighter bicycles, gear-change control on the steering wheel in F1.
- (Useless) swimsuit, player position analysis systems.

What are the important factors for amateurs?

Comfort, safety, control, accuracy.
The images are spectacular: the races of two skiers are superimposed and show the passages in which 1/100ths of a second were gained; an athlete’s long jump is split up into 20 different images.

Video therefore helps coaches to analyse closely an athlete’s movements and trajectory. These systems make it possible to compare players’ styles and to understand better the phases of play in team sports. In particular, they make it easier to compare what the coach sees from the outside and what the athlete feels on the inside.

In the Athletes and Science exhibition: Image processing systems (“SimulCam and “StroMotion”) are exhibited.

HOW ARE STROBOSCOPIC IMAGES MADE?

It is easy to edit images in order to create a stroboscopic effect (see glossary, p.21) if the camera does not move. It is simply a question of selecting which images to show. Since standard digital video cameras record 30 images per second, taking one out of 30 will split the movement second by second. However, the situation is more complex if the camera moves to follow the athlete. In such cases, a computer has to isolate the athlete by removing the background and push the image back on the screen in order to compensate for the movement of the camera (see diagram).

To achieve this, the camera’s movements must be known. Two techniques are used. Movement sensors can be installed on the camera, or the movement can be calculated from the background, which remains fixed.

Similar problems arise in relation to the superimposition of two images (see schema).

Sequences of the left (A and B): the athletes are cropped by special software.
Sequences of the right (A+B): the images are then realigned and superimposed.

As the cameramen follow the athletes through the race, the camera’s angles are never the same from one recording to another. In order to compare the two images, the camera’s movements need to be known in order to proceed as if they had been the same by repositioning the images.
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TV, ATHLETES AND HUMAN RESOURCES

Developed as part of a thesis written at the EPFL and marketed by the young Fribourg company (or “start-up”) “Dartfish”, the “SimulCam” image superimposition technique made its first public appearance in January 1998 at the downhill event in Wengen. It was initially marketed “among” television companies, who wanted to broadcast these spectacular images in order to attract viewers. But coaches very soon began to show an interest.

The “StroMotion” stroboscopic imaging system was launched at a figure skating competition in January 2001. It is now used by judges to mark skaters’ performances. At the Turin Olympic Winter Games in 2006, more than 60% of the athletes and coaches used this type of system. Nowadays, the company also sells its software products to physiotherapists and human resources departments to help them analyse employees’ behaviour. Although many innovations are initially developed for a niche market before being adopted by the general public, Dartfish did the opposite by starting with television and then targeting specialists. This story illustrates how a technology can benefit all stakeholders in high-level sport, from TV viewers to athletes, coaches and judges.

DISCUSSION TOPICS

From chronophotography to perception analysis

In the late 19th century, photographers such as Eadweard Muybridge and Etienne-Jules Marey invented systems for taking photographs in very quick succession: chronophotography. The technique was initially used to study the movements of animals (flight of an insect, a horse’s gallop). The analysis of athletes’ movements therefore became a matter of science, geometry and physics.

In the early days, attention was focused on the most “visible” moments of a movement (such as a long jumper’s trajectory through the air). Around the mid-20th century, analysis switched to the hidden, very brief, most crucial moments, such as a jumper’s take-off. In the 1970s, users of the technique began to search for the “ideal movement”, but in most cases such analysis only detected slight imperfections in certain athletes, some of which could be corrected.

The scientists then turned to the perception and reactions of athletes and discovered, for example, that a goalkeeper generally looks not at the ball, but at his opponent in order to read his body language better.

Use a stroboscope to analyse movement

Stroboscopy can be used to create a photographic image showing the trajectory of an object in several stages. A long exposure is required and the object is lit up with a stroboscope, a device that emits light intermittently (for example, a flash every 0.1 seconds). Stroboscopes are used in physics lessons to study the trajectory of flying objects.

Evolution of image presentation

Consider the theme of images and how they have evolved. What new ways of presenting images are pupils familiar with? For each one, describe how they could change the practice and representation of sport.

• Slow motion, speeded-up motion.
• Split-screen, zapping.
• 3D “bullet time” effect, created using multiple cameras placed around the subject (used in the film “The Matrix”).
• Photographic effects (contrast amplification, fisheye, “tilt-shift miniature” effect).
• Video games in which the action can be played back from various camera angles.
• Augmented reality (see glossary, p.21).
Wearing only gloves, socks, a hat and a mask covering their mouth and nose, athletes enter a room where the temperature is -110 degrees. They stay there for two to three minutes. The purpose of this blast of cold air? To treat injuries, reduce pain and accelerate recovery. But not only that. Athletes use it to reduce the risk of injury during a period of intensive training, or even to prepare for a competition. So, is this a form of doping or not?

“Whole-body cryotherapy” is a very recent phenomenon, and scientists have not yet provided all the answers in terms of its effectiveness. But sport does not wait... The fact that athletes have adopted this technique, which comes straight from a science-fiction book, shows the unbounded creativity shown in high-level sport when it comes to pushing athletes even further. What does it suggest about the sport of the future?

**HISTORY AND PRINCIPLE**

Cold therapy (or cryotherapy) is well known: who has not put an icepack on a swollen wound? Greek doctor Hippocrates recommended the use of ice and snow on injuries 400 years BC. The cold reduces the swelling (or inflammation) by constricting the blood vessels, which reduces blood flow. It also alleviates pain by reducing the transmission of nerve impulses.

Cold can also be applied to the whole body. Ice baths are a tradition in many Nordic countries (Scandinavia, Russia), and some sports teams use them after training in order to prevent stiffness and encourage muscle recovery.

Cryotherapy chambers were developed in Japan in the 1980s before being imported by Germany and Poland, initially to treat problems such as rheumatism or arthritis (inflammation of the joints). This treatment was available in a small number of medical establishments, often linked to spas. It remained controversial because few scientific studies had been carried out on the subject. Nevertheless, beauty salons began to offer it as a way of reducing cellulite.

**ATHLETES TRY IT OUT**

Athletes very quickly showed an interest in this new technique, initially for post-injury rehabilitation. The pain relief, which lasts for several hours after treatment, helped them to carry out physiotherapy exercises. “If two athletes train the same way, the one who recovers better is more successful”, said a specialist.

Some teams receive cryotherapy treatment during intensive training sessions in order to reduce the risk of injury. Athletes [such as the Irish rugby team, for example] use it regularly during the season to improve their performances, or even just before a competition. However, scientists remain unconvinced about whether it improves performances. It seems that cold can help with endurance events (especially in hot and humid conditions), but less so with intense effort such as sprinting.

Cryotherapy illustrates perfectly how an innovation can find its place in society. Whereas the medical applications are developing steadily, with a degree of caution and via rigorous scientific studies, beauty salons are not slow to make use of the techniques as soon as they become marketable (i.e. harmless and potentially effective). Athletes also do not wait long to test out these methods in the hope of improving their performance. In these cases, word of mouth works well: if stars do it and are satisfied, others will follow suit...

And what would you do? Would you step into a deep freeze?

In the Athletes and Science exhibition: The exhibition does not show a cryotherapy chamber, but an altitude chamber, which is similar (see p.5).
THE CRYOTHERAPY CHAMBER IN PRACTICE

The session is supervised by paramedical staff. Complete a medical questionnaire (patients with high blood pressure or heart problems should be excluded). Get undressed, put on thick socks, gloves, a headband over the ears and a surgical mask over the mouth and nose. Then enter... After passing briefly through one airlock at -10°C and another at -60°C, you enter the chamber at -110°C. Body temperature does not drop, or only slightly. Skin temperature can reach 10°C, or even 5°C – as when ice or a coldpack is applied locally.

Stay for a few minutes at most. You have to move around a bit. The cold is biting, say users, but not as unbearable as they expected. You can communicate via a microphone and loudspeakers with the operator who is monitoring the chamber. After coming out again, patients say they are delighted, in good shape and already slightly addicted – they want to go back the next day.

DISCUSSION TOPICS

Why doesn’t the body freeze at -110°C?

Hot or cold sensations depend less on temperature than on the transmission (loss or gain) of heat: a wooden object always appears rather lukewarm, whether at 10°C or 40°C, because wood does not transmit heat well – unlike metal or concrete, which seem to get very cold or very hot extremely quickly. Water is a good thermal conductor, which is why an ice bath becomes unbearable very quickly and why a dry winter’s day seems warmer than a wet autumn day. The air in the cryotherapy chamber is very dry and still (no wind) and the rate of heat transmission remains low. However, extremities (feet, hands and ears) need protection, since they are in danger of freezing because they have a smaller blood supply. A mask protects the mucous membranes of the mouth and nose.

Is it a form of doping and should it be banned?

Organise a debate between two groups, each provided by the teacher with a number of arguments for and against.

Doping is defined as “the use of products that temporarily improve athletic performance”.

Against:
• Doping only concerns chemical products;
• Cryotherapy does not damage health, which is all that matters;
• It is similar to an altitude chamber, which is allowed;
• Methods should not be banned, but certain physiological states that are abnormal or dangerous for the athlete.

For:
• It is an “artificial” technique;
• There need to be limits. Otherwise, athletes will do all sorts of bizarre things before competing;
• Should only be allowed for medical purposes.

The future of sport

How do you imagine athlete preparation in the future?
(see «Suggestions for further study», p.20).
DISCUSS THE GROWING INFLUENCE OF TECHNOLOGY IN SPORT

What do the pupils think of it? Is there still room for the athlete? But is it really possible to practise sport without technology? How could society, even if it wanted to, slow down the progress of innovation, which is fostered by people’s fascination with technology, coaches’ expectations, financial incentives and pressure from the media for more records and excitement?

LIST TECHNOLOGIES AND THEIR INFLUENCE ON SPORT

Draw up a list of all technologies (whether presented in the exhibition or not), their influence on the different stakeholders of high-level sport and their usefulness for amateurs.

For example:

• Slow motion replays (in all sports). For referees, coaches and spectators.
• Measurement of speed (in all races, or serves in tennis). For coaches, spectators and sports commentators.
• Numerous new materials (such as carbon fibre, for example).

IMAGINE THE SPORT OF TOMORROW

Look again at the themes covered in the “ScienTekCity” section. What might sport look like in 100 years’ time?

In the form of a discussion or workshop. A list of technological innovations is given to the pupils, who must imagine how each of them might change sport for athletes (A), coaches (C), judges (J) and (television) viewers (V).

Innovations:

• Extraordinary materials: super slippery, adhesive, elastic, lightweight, solid, malleable, aero- and hydrodynamic, even an “invisibility cloak” (A).
• Augmented reality involves the superimposition of computer data on the natural perception of reality: wireless connection and instant data transmission, locating opponents, ball position and speed, the physical condition of players, pitch conditions (C, J, V).
• Artificial intelligence would analyse numerous factors in order to determine the best strategy (used in Alinghi sails, for example) (A, C).
• Towards the cyborg, a combination of man and machine: high-performance artificial limbs (see the example of disabled athlete Oscar Pistorius and his “Cheetah” artificial limb), direct connection between the nerves, brain and computers helping the athlete to analyse the game and strategy.

WOULD MORE TECHNOLOGY BE GOOD FOR SCHOOL SPORT?

Analyse the possible usefulness of hi-tech tools in school sport (see bibliography, p.22).

• For which sports and in what form?
• How much will it cost (in money and time)?
• Will it really be used? Estimate the time needed to set up the equipment and transfer, examine and analyse the results.

A project can then be carried out in collaboration with teachers of sport, physics (for measuring devices), biology (for the physiological aspects) and mathematics (for the statistical analysis of data).
3.2 GLOSSARY

Visual acuity
Ability to distinguish between two points very close together.

Aptitudes
An individual’s physical and mental abilities to accomplish a certain task.

Chronophotography
Method of analysing movement by creating a succession of photographs.

Horizontal coefficient of friction
Number depending on the shape of an object that describes the force of resistance to its horizontal movement in a fluid.

Cryotherapy
Cold therapy.

Hypoxia
Lack of oxygen, such as at the top of a mountain or in an altitude chamber.

Body fat percentage
Relationship between the weight of fat and total body weight.

Stroboscopic image
Photographic technique in which the intermittent illumination of a moving object produces a succession of images showing its trajectory.

Metabolism
Transformation of molecules and energy that takes place in cells [by extension: the muscular or respiratory aptitudes of the body].

Performance
Result achieved by the athlete or team during training or competition.

Photo-finish
Photograph of competitors at the end of a race, used to separate them.

Touch pad
Pad that a swimmer has to press to signal the end of the race.

Polyurethane
Plastic polymer [macromolecule], used in various forms [rigid foam, flexible or hard plastics, etc.] and found in the latest swimsuits.

Augmented reality
Superimposition of computer data on a real image [e.g. the “WorldPeaks” iPhone application, which indicates the direction and altitude of the nearest mountains].

Science
Study and analysis of the laws governing phenomena.

Technology
Technological processes and applications originating in science.

Reaction time
Latent period between the presentation of a stimulus [auditory, visual, etc.] and the voluntary motor response to that stimulus.
SCIENCE AND SPORT

Tara Magdalinski
Sport, technology and the body: the nature of performance
London: Routledge, 2009

Stewart Ross
Higher, further, faster: is technology improving sport?

Joanne Thatcher
Sport and exercise science
Exeter: Learning Matters, 2009

Margaret Estivalet
The engineering of sport 7

David Kirk
Key concepts in sport and exercise sciences
Los Angeles: Sage, 2008

Science Daily
www.sciencedaily.com/gallery/matter_energy/sport_science

FOCUS ON 3 TECHNOLOGICAL INNOVATIONS

Polyurethane swimsuits
Analysis of the physics of swimming:
• Les bases biomécaniques de la natation, Sciences et techniques des activités physiques et sportives, Université Paris 13, www.smbh.univ-paris13.fr/staps/A_Aqua.htm
• Stage FPC Natation, Régis Fayaubost, Académie d’Antibes, 2007
  www.mapreps.com/FPCnat_fayaubost.pdf
• Comparison between the drag coefficients of different shapes
  en.wikipedia.org/wiki/Drag_coefficient

Image processing: from spectators to coaches

Dartfish
www.dartfish.com/fr/index.htm
Use of the Dartfish stroboscopic imaging system in school sport: tinyurl.com/ygvv8a6

Virtual exhibition on Marey
www.expo-marey.com/home.html

Other technologies presented in the exhibition

Myotest
www.myotest.ch/Home.aspx

Hawk eye
www.hawkeyeinnovations.co.uk/?page_id=1008&PHPSESSID=05353571008506c9888f00d2c59d67a2

Batak
www.batak.com et tinyurl.com/yds76s8
WAYS OF VISITING THE ATHLETES AND SCIENCE EXHIBITION FROM 5 MAY 2010 TO 13 MARCH 2011

Guided tour and workshop
At the Museum, classes can visit the exhibition with a guide. Their visit continues with a workshop based on a historical approach: focus on a few symbolic sports with video clips of Olympic competitions through the ages, comparisons of sports equipment and practical exercises.
For 8-16 year olds. Duration: 1h30
Information and reservations: +41 [0]21 621 67 27 or edu.museum@olympic.org.

Independent visit

Opening hours
The Museum is open every day from 9 a.m. to 6 p.m.
Closed on Mondays between 1 November and 31 March.

Prices
Schools (compulsory schooling) CHF 6.–/pupil
Accompanying adult/10 pupils free
Guided tour for schools (with workshop) CHF 50.–
Children aged 6–16 and students (individual) CHF 10.–
Adults (individual) CHF 15.–

GETTING TO THE MUSEUM

By metro
M2 (direction Ouchy): Ouchy or Délices stop

By bus
Bus 8 and 25: Olympic Museum stop
Bus 4: Montchoisi stop

By car
Motorway exit Lausanne-Sud. At the roundabout, follow the road along the lake as far as Ouchy, then follow the signs to The Olympic Museum.

Parking
Parking spaces on Quai d’Ouchy or in the Port d’Ouchy car park (entrance in front of the Mövenpick Radisson hotel).

Access for people with reduced mobility
North entrance of the Museum.
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