LET'S SCIENCE!

2

Francesco Oliva

LET'S MOVE!

The benefits of a life
on the move

IBSA FOUNDATION for scientific research

LET'S SCIENCE!

Francesco Oliva

LET'S MOVE!

The benefits of a life on the move

IBSA FOUNDATION for scientific research

Repubblica e Cantone Ticino
Dipartimento dell'educazione, della cultura e dello sport

Original edition: *Muoviamoci! I benefici di una vita in movimento* (Carocci, 2019)

Graphic project by Ulderico Iorillo and Valentina Pochesci

CONTENTS

PREFACE

How familiar are we with the repercussions of scientific research and medical practice for our daily lives? What are the “passions” and motivations that drive researchers and healthcare professionals? What do we know about their professions?

Society strives to make science and its implications known to ordinary people in many different ways. Just think, for example, of the variety of leaflets promoting the importance of a healthy lifestyle and well-being in general. Of course, school does its part as well, introducing the principles of scientific literacy and raising awareness of a series of issues that help foster scientific thinking among young people.

These considerations are in fact the starting point for the *Let’s Science!* project, carried out by the IBSA Foundation for Scientific Research in collaboration with the Department of Education, Culture, and Sport of the Canton of Ticino (DECS). The partnership has made it possible to identify interesting topics that have been addressed by the project, getting scientists working in the canton involved. Two different worlds that are often far apart – scientific research and school – have thus been brought together, promoting dialogue between professionals and students through themed workshops, in order to develop awareness of both the topic itself and how to communicate it.

But what was the range of topics the project would address and what considerations led to certain strategic decisions? Science and research are advancing rapidly, especially in biomedicine and related disciplines, and the continuous expansion of fields of investigation requires a constant effort to stay up to date, in order to both maintain a historical perspective and accommodate the numerous innovations. Access to scientifically accurate information, conveyed in accessible language, opens up the opportunity for children to get to know and become passionate about topics that are generally considered “difficult”.

And that’s the idea behind the *Let’s Science!* series, which aims to broaden the range of scientific topics that can be explored at school. The topics, which are interdisciplinary and directly related to individual health and well-being, are presented in an innovative way: the scientific text is in fact accompanied by a story that draws on the experience of cantonal middle school classes, who, under the guidance of their teachers, developed original scripts, which were then translated into comics by professionals in the industry.

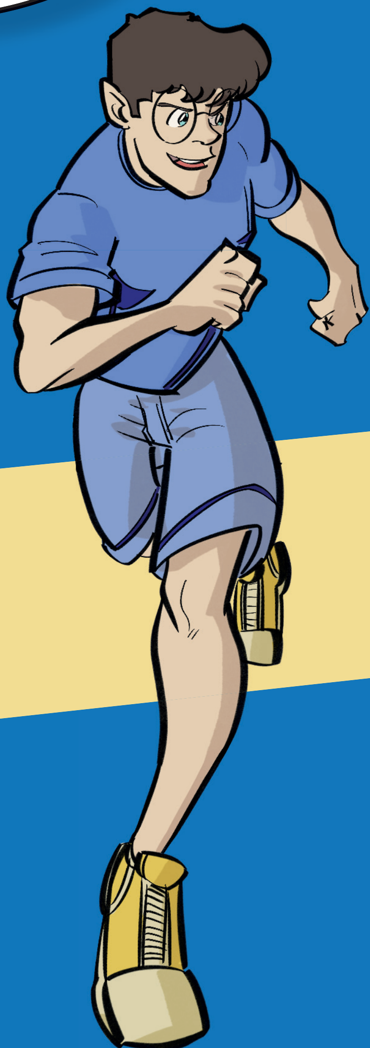
The only thing left for us to do is invite young readers to explore the fascinating fields of research presented by *Let's Science!*, which in turn open up opportunities for further questions and insights. Who knows, one of these readers might in turn one day become the one taking important steps forward in understanding the complexity of life and the delicate balance that allows us to be healthy and happy. Enjoy reading!

SILVIA MISITI
Director of the IBSA Foundation for Scientific Research

NICOLÒ OSTERWALDER
Educational consultant for science at the Department of Education (DECS)

Let’s move!

PART ONE



INTRODUCTION

Movement and the energy we continually convert enable us to live. Today, in our increasingly technological society that keeps us stuck in front of a computer screen or connects us globally through a tablet or a mobile phone, human beings are paradoxically at risk of moving less and less. Our lives move faster and faster, and we can find out everything that happens in every part of our world, but all without taking a single step. The biggest risk of our times is therefore a sedentary lifestyle.

In fact, **lack of movement** is the fourth most important risk factor for mortality: 3.2 million people die each year as a result of sedentary living, including one million deaths in Europe alone. In addition, levels of physical inactivity are increasing in many countries, with serious consequences for the general health of the population.

Physical inactivity is a key risk factor for non-communicable diseases, such as osteoporosis and joint degeneration (osteoarthritis), cardiovascular diseases, cancer, and diabetes. According to a 2009 World Health Organization (WHO) report (*Global health risks: mortality and burden of disease attributable to selected major risks*), a sedentary lifestyle is estimated to be the leading cause of about 21-25% of breast and colon cancers, 27% of diabetes, and about 30% of heart attacks. Moreover, the number of overweight and obese people has been increasing rapidly in recent decades. In 46 European countries, the percentage is over 50% and as high as 70% in several cases.

What is particularly worrying, in terms of the future, is the lack of physical activity especially among young people. In Europe, six out of ten adolescents over the age of 15 never exercise or play sports.

In addition to the physical consequences, inactivity also reduces the ability to manage stress and decreases the opportunity to meet people and thus to socialize.

This is why the WHO published the *Global Recommendations on Physical Activity for Health* in 2010, providing guidance on the levels of physical activity that everyone should engage in.

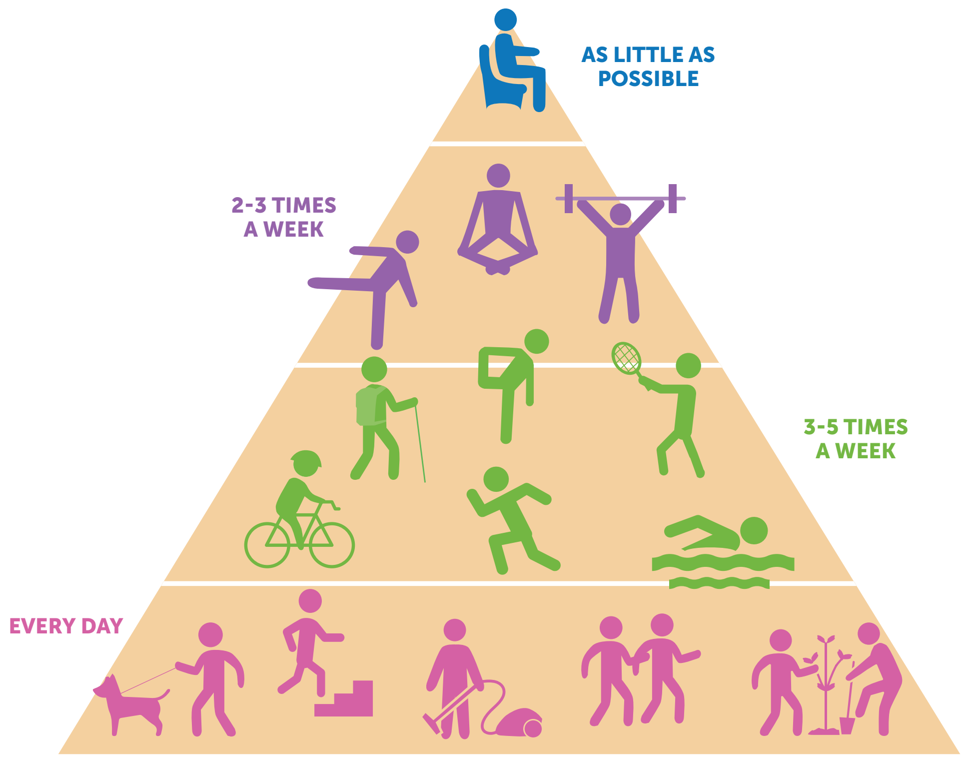
What do we mean by **physical activity**? According to the WHO, physical activity is "any effort exerted by the musculoskeletal system that results in a higher energy expenditure than in resting conditions". This definition therefore includes not only sports activities, but also simple movements such as walking, cycling, dancing, playing, gardening, and housework, which are included under "spontaneous physical activity" (SPA). **Exercise**, on the other hand, is a subcategory of physical activity that is planned, structured, repetitive, and intentional, and is aimed at the goal of achieving physical fitness. But how much movement do we need to stay healthy?

The goals we should strive for are **60 minutes a day for children and adolescents** (ages 5 to 17) and **150 minutes a week for adults** (ages 18 to 64), which can be distributed across various sessions throughout the day. The WHO recommends starting with moderate physical activity and then gradually progressing towards higher levels of intensity [**figure 1**].

In the report *Health in the Canton of Ticino 2012*, it says that "between 2002 and 2012, the percentage of physically active people in the Canton of Ticino rose from 52.9% to 60.8%, while the proportion of inactive people fell from 32.0% to 21.5%. The trend at the national level was similar over the same period of time. By way of comparison, in 2012, the average proportion of active people in Switzerland was 72.5% and the proportion of inactive people was 10.7%. The proportion of active people drops as age increases: in the 15-34 age group, 70.9% of the inhabitants of Ticino are active and 13.0% are inactive; in the 65 and older age group, the percentage of active people is 55.4%, while 32.9% are inactive. It should be noted that in Ticino, as in Switzerland, men aged 65 and over engage in physical activity more often than women (65.5% compared to 47.3%) (Journal of the Swiss Health Observatory [OBSAN] 08/2014). The improvement in the situation shows that here as well, the policies implemented to prevent physical inactivity are bearing the desired fruit".

Switzerland, through the Swiss Federal Office of Sport (UFSPO), has also issued **recommendations on movement** and the role it plays in preventing a whole range of diseases affecting the musculoskeletal system, as well as other diseases. The basic document *Moving is Good for your Health*, produced by

Figure 1 The Pyramid of Physical Activity



the Federal Office of Sport (UFSPO) and the Federal Office of Public Health (UFSP), emphasizes that, in Switzerland, physical inactivity causes death, disease, and high health costs: every year, there are at least 2,900 premature deaths, 2.1 million cases of diseases, and direct health costs amounting to CHF 2.4 billion.

In 2016, the WHO published another document, the *WHO Physical Activity Strategy 2016-2025*, calling on all European governments to take concerted action to increase the levels of physical activity all citizens engage in. The goal is to **reduce physical inactivity by 10% by 2025**, which will reduce premature mortality from cardiovascular disease, cancer, and chronic respiratory diseases by 25% and slow down the sharp rise in diabetes and obesity.

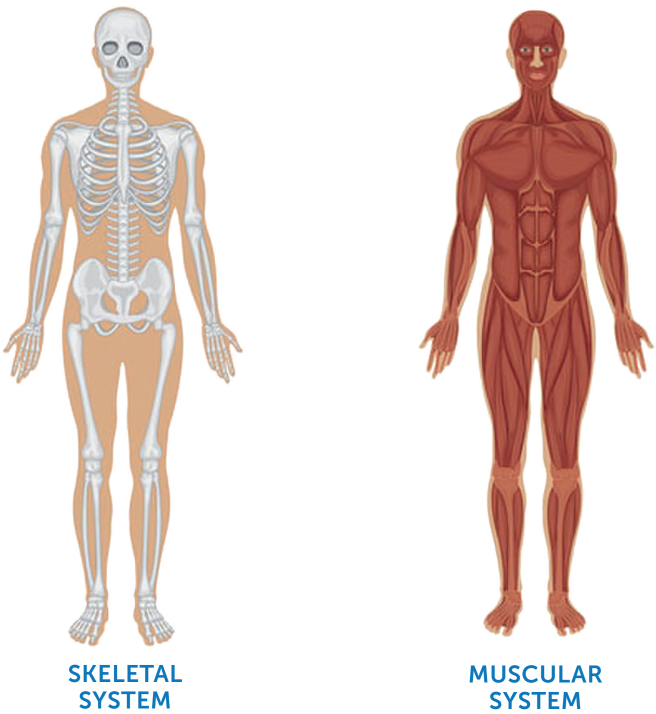
WHAT HAPPENS TO OUR BODIES IF WE DON'T MOVE?

The human body is made to move, but all the organs and structures that make up the **locomotor system** or musculoskeletal system [**figure 2**] need continuous stimulation to stay efficient.

The **musculoskeletal system**, which makes up 70% of our body mass, is made up of:

- 206 bones of various shapes and sizes;
- 752 muscles, of which 327 are skeletal muscles, which attach to the bones and are necessary for motor function;
- 267 tendons, fibrous structures that attach the muscles to the bones or skin, enabling the contractile tissue to perform its functions;

Figure 2 The musculoskeletal system



- about 360 joints, structures that hold the various segments of bone together;
- ligaments, fibrous structures that connect two bones or two parts of the same bone together.

Its main functions are to support our weight, protect our visceral organs and, as we said, enable us to move. At birth, the musculoskeletal system is very different; it changes as we grow during childhood and adolescence, then consolidates in adulthood and, finally, wears down as we age.

The bones, in particular, are subject to a continuous process of renewal that modifies them until we finish growing, when they reach their maximum strength and mineral density. This moment is called **peak bone mass** and occurs around age 16-18 in females and around 20-22 in males. From this point on, bone density and size no longer increase.

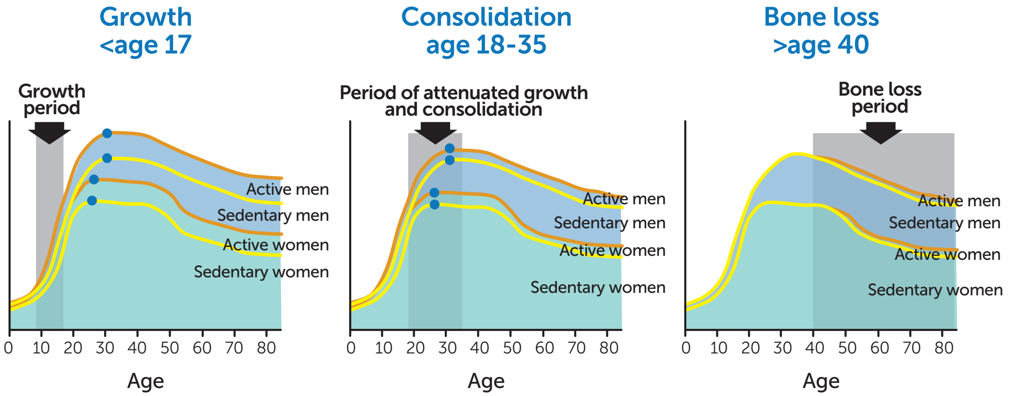
In general, the factors that determine peak bone mass are:

- genetics associated with hereditary factors;
- vitamin D and nutrients needed for bones, such as calcium and protein;
- endocrine factors, such as sex hormones;
- physical activity;
- body weight.

Bone mass is continually reabsorbed and rebuilt throughout our life, but as we age, the amount of bone lost is not replaced by an equal amount of new bone. Following a healthy lifestyle and, above all, constantly engaging in physical activity before reaching peak bone mass, while they are still growing, can help young people to accumulate more bone mass and ensure better bone quality in adult life as well [**figure 3**].

In short, our musculoskeletal system is complex and finely regulated and it needs to be used in order to function at its best. It interacts with the other organs and tissues of the body, so it is essential to treat it with the due respect, since ultimately, taking care of it means looking after ourselves.

Figure 3 Reaching peak bone mass



Researchers have developed various systems to understand what leading a sedentary lifestyle does to our musculoskeletal system. Especially since the 1970s, several **experimental models** have been developed that replicate the basic conditions (for example, the selective immobilization of a joint in animal models, or sedentary living or periods of bed rest in human models), which have facilitated the progress of medical knowledge and, consequently, the development of effective therapeutic strategies.

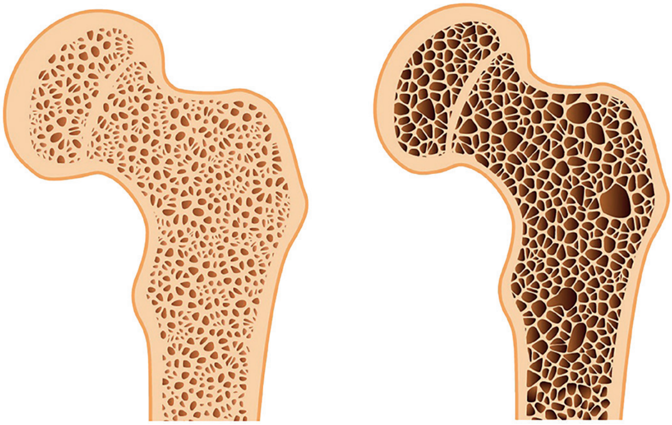
WHAT ARE THE EFFECTS OF A SEDENTARY LIFESTYLE ON OUR BONES?

A sedentary lifestyle can cause a **decrease in the mineral and cellular content** of our bones. This can happen both during the growth period and in adults and the elderly, and it is scientifically proven to be one of the most important causes of osteoporosis.

What is osteoporosis?

Osteoporosis is a disease that makes the skeletal system weak and fragile [**figure 4**]; it is particularly widespread in industrialized countries and especially affects women. Those who suffer from this disease are more likely to suffer vertebral

Figure 4 Effects of osteoporosis on bone



and femoral fractures that cause pain, immobility, and disability, as well as a considerable reduction in their quality of life.

The disease is characterized by qualitative and quantitative **changes** in the **bone tissue**, which consists of 3 different components: organic, mineral, and cellular.

- **Organic component**: this constitutes a kind of framework (bone matrix), formed by long fibrils of a protein called **collagen**, which gives **elasticity and cohesion** to the overall structure.
- **Mineral component**: this is formed by crystals of calcium, phosphorus, and magnesium salts, as well as other elements that are deposited on the organic matrix; it ensures the bones are **sturdy and able to support the weight of the body**.
- **Cellular component**: this consists of specialized cells that regulate the level of bone mineralization: some of these cells (**osteoclasts**) destroy the “old” bone, while others (**osteoblasts**) regenerate the “new” bone. These cells are responsible for renewing the bone every day, throughout life. This process of synthesis and breakdown is called **bone remodeling**. The resorption phase is mediated by osteoclasts, which erode a small amount of bone, forming a microscopic cavity; in this phase, cal-

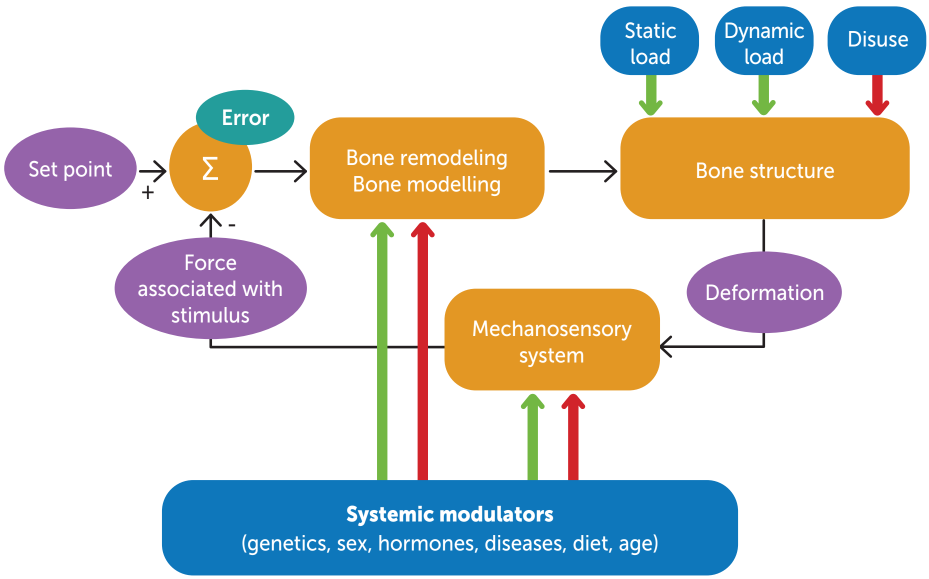
cium and other minerals (phosphorus, magnesium, etc.) contained in the skeleton are released into the blood. As soon as the osteoclasts cease their activity, the osteoblasts rebuild new bone in the cavities eroded by the osteoclasts (**neoformation**); in this phase of reconstruction, calcium and phosphorus are reabsorbed from the blood. In healthy bone, for every area where breakdown is occurring, there is always another where reconstruction is occurring, so that the bone always maintains its structure and sturdiness while renewing itself; the two phases therefore tend to be in perfect **balance**. However, physiologically, in some phases of life this balance is lacking; in fact, while an individual is growing, and especially during **puberty**, neoformation prevails over resorption to enable the skeleton to grow and develop. Subsequently, during **adulthood**, neoformation and resorption are balanced to preserve the tissue that has been built. Finally, in **old age**, breakdown tends to prevail over reconstruction and thus the bone becomes weaker.

Figure 5 shows the outline of homeostasis in the bones under the various kinds of load. The green arrows represent static and dynamic loads due to muscle contraction and locomotion, while the red arrows represent disuse or a lack of load. **Osteocytes**, part of the cellular component of bone tissue, sense spatiotemporal changes through a mechanosensory system, resulting in bone remodeling. The absence of loads causes a loss of bone mass, while loads strengthen the bones.

In adults, the risk factors for osteoporosis are:

- being female;
- advanced age;
- family history;
- low body weight;
- smoking cigarettes;
- physical inactivity or prolonged immobilization;
- low calcium intake (calcium can be found mainly in milk, dairy products, and grains and the recommended daily intake is 1,000-1,200 mg for adults);

Figure 5 Homeostasis in bones



- a vitamin D deficiency [**table 1**];
- alcoholism;
- hyperparathyroidism;
- estrogen deficiency;
- some medications;
- various diseases: systemic (e.g., hypothyroidism); rheumatic (e.g., rheumatoid arthritis); hematological (e.g., thalassemia); and neoplastic (e.g., leukemia).

Can osteoporosis affect young people as well?

Although the WHO has not defined primary risk factors for osteoporosis in children and adolescents, certain diseases such as **anorexia nervosa** and **obesity**, which are increasingly prevalent among young people, are causes of secondary osteoporosis in these age groups.

Table 1 Vitamin D intake recommended by the Endocrine Society Guidelines Committee

AGE	MAXIMUM RECOMMENDED DAILY DOSE
0-12 months	2,000 IU
1-18 months	4,000 IU
>18 months	10,000 IU
Pregnancy (18+ years)	10,000 IU
Breastfeeding (18+ years)	10,000 IU

Obese children have greater bone strength, but it is still disproportionate to their body weight, helping to increase the risk of fractures.

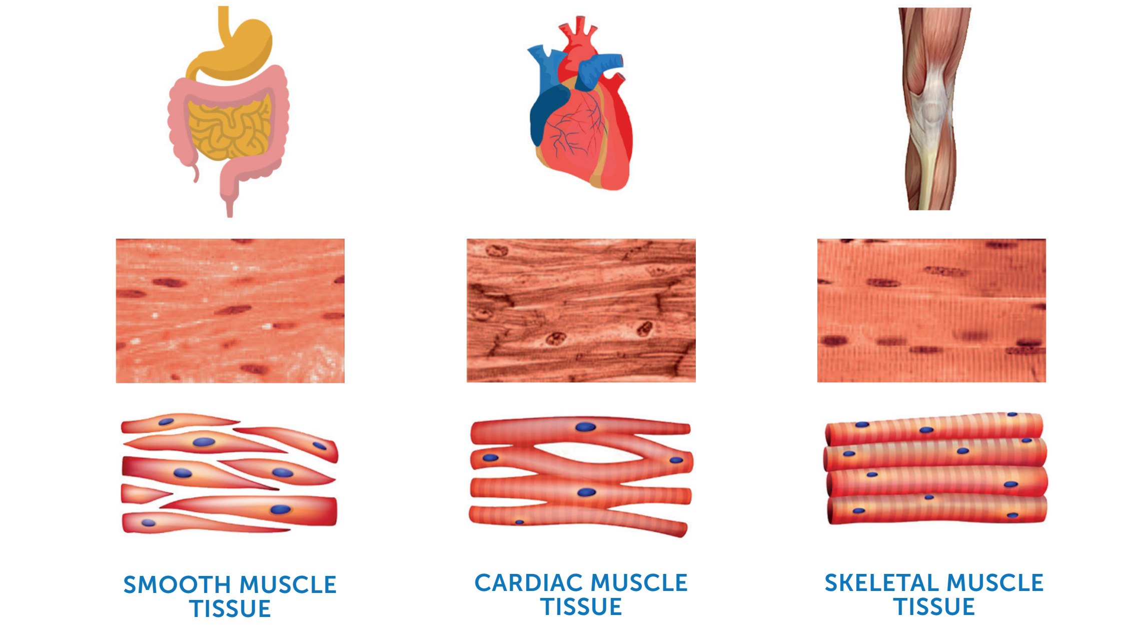
Children and adolescents who are obese or anorexic may in fact have impaired bone strength during development, resulting in problems with their musculo-skeletal system.

AND WHAT HAPPENS TO OUR MUSCLES IF WE DON'T MOVE?

Muscles are contractile organs made up of fibers that, when they shorten as a result of a nerve stimulus, cause the parts on which the muscle is inserted to move. There are three types of muscle [**figure 6**]:

- **smooth muscles** that are characterized by the absence of transverse striations and line the internal organs (for example, the stomach, intestines, etc.); they are involuntary muscles, meaning that we cannot move them intentionally;
- **striated muscles** that have a direct relationship with the skeleton (skeletal muscles) and enable us to move our joints, generate heat, and protect our bones; they are voluntary muscles, meaning that they respond to our commands;

Figure 6 The three types of muscle tissue



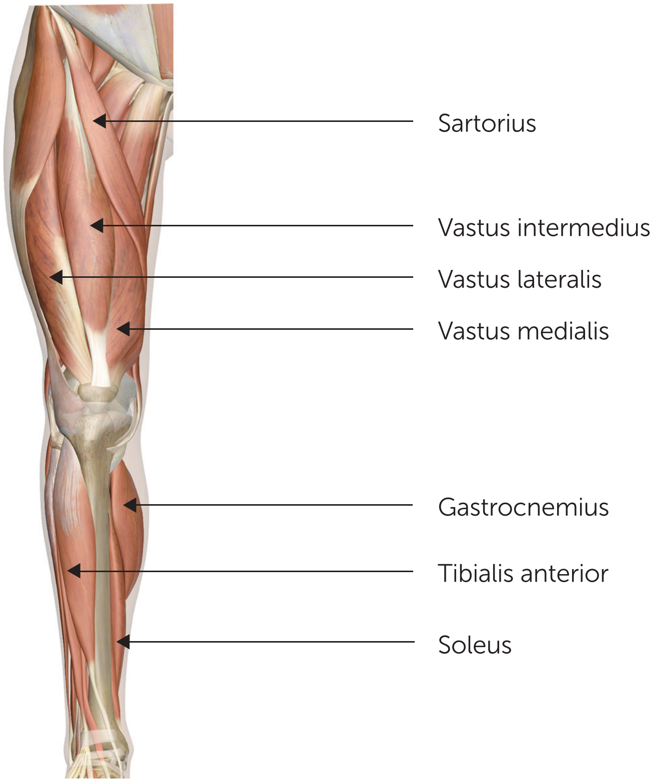
- the **heart muscle** or **cardiac muscle** is a special muscle; in fact, although it is a striated muscle, it is involuntary.

Even just a few days without the skeletal muscle being subjected to load, i.e., of inactivity, are enough to decrease its cross-sectional area, or **CSA** (imagine, for example, measuring the circumference of the thigh with a tape measure, as is done to assess the loss of muscle tone after a fracture that required immobilizing a leg). This cross-sectional area can also be thought of as the volume of muscle fibers that produce energy and force by contracting. After only 7 days of bed rest, a muscle that works against gravity, such as the vastus lateralis (one of the 4 thigh muscles) [figure 7], starts to atrophy.

Muscle fibers are classified into:

- **type I fibers (slow-twitch or red fibers)**, characterized by a high energy demand to complete a **slow contraction**, typical of the initial phase of exercises; they are prevalent in athletes who perform slow and prolonged exercises and in sports such as marathon running;

Figure 7 The muscles of the quadriceps femoris



- **type II fibers (fast-twitch or white fibers)**, responsible for rapid and intense contractions thanks to their ability to use the energy substrates accumulated in the muscle; they are prevalent in individuals who carry out intense and rapid exercises.

Under conditions of inactivity, muscles undergo something called **disuse atrophy**: as the energy necessary for the metabolism of type I fibers is lacking, their number decreases in favor of an increase in type II fast-twitch fibers [**table 2**].

A number of studies have been conducted during spaceflight, bed rest, immobilization (in plaster), and step reduction to assess the molecular and cellular changes that occur in a disused muscle. Studies show that for each day of immobilization, there is a loss of contractile strength of about 1-1.5%.

Table 2 Muscle fibers

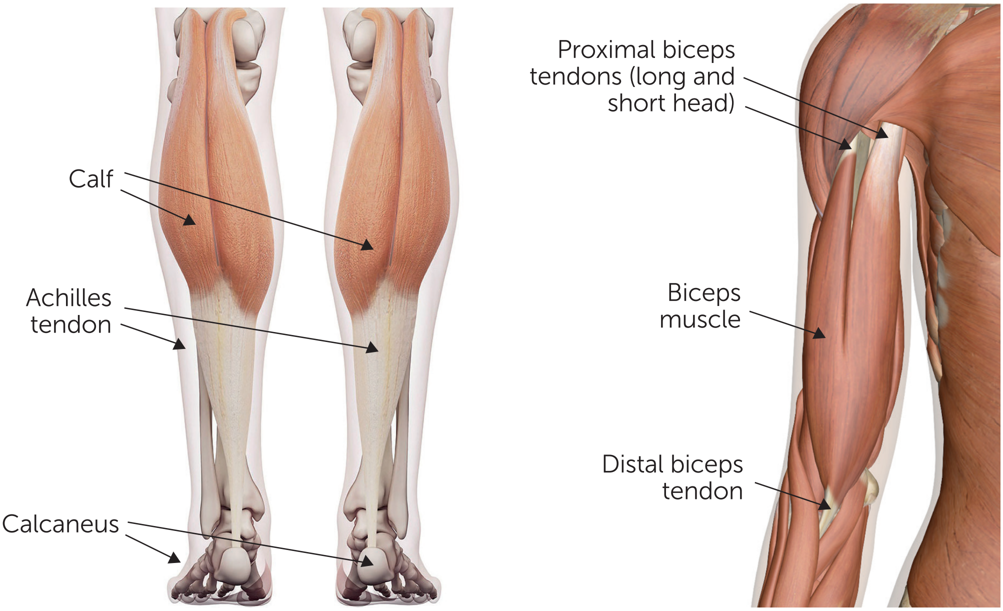
	TYPE I FIBERS (slow-twitch or red)	TYPE IIA FIBERS (intermediate)	TYPE IIX FIBERS (intermediate white)	TYPE IIB FIBERS (fast-twitch or white)
Contraction speed	Slow	Moderately fast	Fast	Very fast
Motor neuron size	Small	Medium	Large	Large
Resistance to fatigue	High	Fairly high	Intermediate	Low
Type of activity for which they are responsible	Aerobic	Prolonged anaerobic	Short-term anaerobic	Short-term anaerobic
Maximum duration of use	Hours	<30 minutes	<5 minutes	<1 minute
Power output	Low	Medium	High	Very high
Mitochondrial density	High	High	Medium	Low
Capillary density	High	Intermediate	Low	Low
Oxidative capacity	High	High	Intermediate	Low
Glycolytic capacity	Low	High	High	High
Main fuel storage	Triglycerides	Phosphocreatine, glycogen	Phosphocreatine, glycogen	Phosphocreatine, glycogen

So, just avoiding a sedentary lifestyle by engaging in sports activity or exercise at all ages will cause our musculoskeletal system to adapt, helping us avoid conditions such as osteoarthritis and osteoporosis.

OUR TENDONS ALSO LOSE FUNCTION IF WE DON'T MOVE AROUND

Tendons are tissues that specialize in transferring the movement of contractile muscle to the joints. They are composed of cells called **tenocytes** and **collagen fibers** arranged in a linear and aligned structure. Tendons, like all the connective tissues in the musculoskeletal system, are also sensitive to loads

Figure 8 Tendons



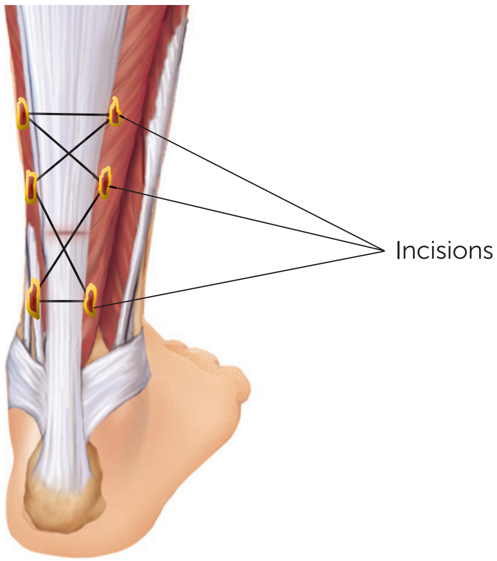
and are equipped with a complex mechanosensory system that regulates the homeostasis of the tissue itself [**figure 8**].

Many intrinsic and extrinsic factors are involved in the regulation of tendons: aging, sex, anatomical variation, certain systemic pathologies such as dysmetabolism (metabolic dysfunction), certain drugs (for example, fluoroquinolones, broad-spectrum antibiotics), excessive loads during sports activities, and external environmental conditions.

A lack of loads on the tendons causes **catabolic effects**, such as the loss of cellularity and substances essential for their elasticity; in certain conditions, excessive loads can also be harmful, while the abrupt interruption of physical activity (detraining) or discontinuous physical activity can cause alterations in the tendon structures that predispose the individual to inflammation or tendon ruptures.

When a tendon becomes pathological, it can undergo a rupture; if this happens, it must be repaired very quickly before the phenomena caused by the lack of function become prevalent and prevent anatomical repair, as in the case of Achilles tendon ruptures [**figure 9**].

Figure 9 Rupture of the Achilles tendon



Although in the past, the rupture of a tendon required very long recovery times, today, fortunately, some surgeons have developed minimally invasive techniques that enable the time away from sport and work to be decreased.

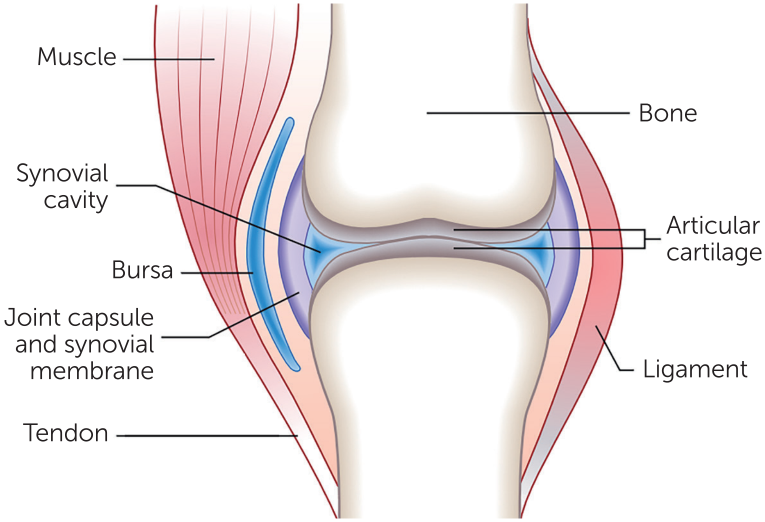
Tendons are often confused with the ligaments, but they are actually different anatomical structures. Although both are made up of collagen fibers, tendons connect muscles to bones or to other insertion structures, while **ligaments** connect different bones or parts of the same bone together.

Are tendons and ligaments the same thing?

OUR JOINTS ARE NOT DESIGNED TO BE IMMOBILE

The joints are a set of structures of our musculoskeletal system that keep two or more bone surfaces contiguous; as functional units, they can rightly be considered organs. We have at least 360, which have different shapes and degrees of mobility; those that make up the cranial vault, for example, have

Figure 10 Articular cartilage



almost zero capacity for movement. The joints make our every move possible, including walking.

They are covered with **articular cartilage**, an elastic tissue with considerable resistance to pressure and traction. It functions like a shock-absorber that safeguards normal articulated relationships and enables movement [**figure 10**].

We typically distinguish between three types of cartilage tissue in our body, each with different characteristics and functions.

- **Hyaline cartilage**: bluish white, **it is the most abundant type of cartilage**. It forms a large part of the skeleton in fetuses; as we grow, it is replaced almost completely by bone tissue, in the process of bone formation. In adults, it forms the cartilage in the ribs, nose, trachea, bronchi, and larynx and covers the joint surfaces. The cartilage is covered with a thin sheath of compact connective tissue, called the **perichondrium**. This tissue disappears near the joint surfaces.
- **Elastic cartilage**: opaque yellow in color, it has special **elastic** properties. It forms the scaffolding of the auricle, epiglottis, Eustachian tube, and some laryngeal cartilages.

- **Fibrous cartilage**: whitish in color, it is particularly **resistant** to mechanical stresses. It is located at the insertion points of some tendons on the skeleton, in the intervertebral discs, in the menisci of some joints (such as the knees), and in the pubic symphysis.

One of the most common joint pathologies is **osteoarthritis** (also sometimes called **arthrosis**) [**figure 11**], which affects not only the hyaline cartilage, destroying it, but also all other structures. A sedentary lifestyle, along with other factors, can cause and accelerate the degenerative process [**table 3**].

Osteoarthritis is a chronic disease characterized by **the loss of joint cartilage**, which is replaced by new bone tissue, causing pain and restricting movement. The most frequently affected joints are those in the hands and feet, knees, hips, and spine.

It is a widespread condition, especially in adulthood: it is present in the majority of human beings by the age of forty and in almost all by the age of seventy, reaching a peak of maximum incidence between the ages of 75 and 79. Before the age of 45, men are most affected; after that age, women are most affected.

It has been shown, in several animal and human experimental models, that immobilization alters the biomechanical and morphological properties of hyaline

Figure 11 Normal joint and joint with osteoarthritis

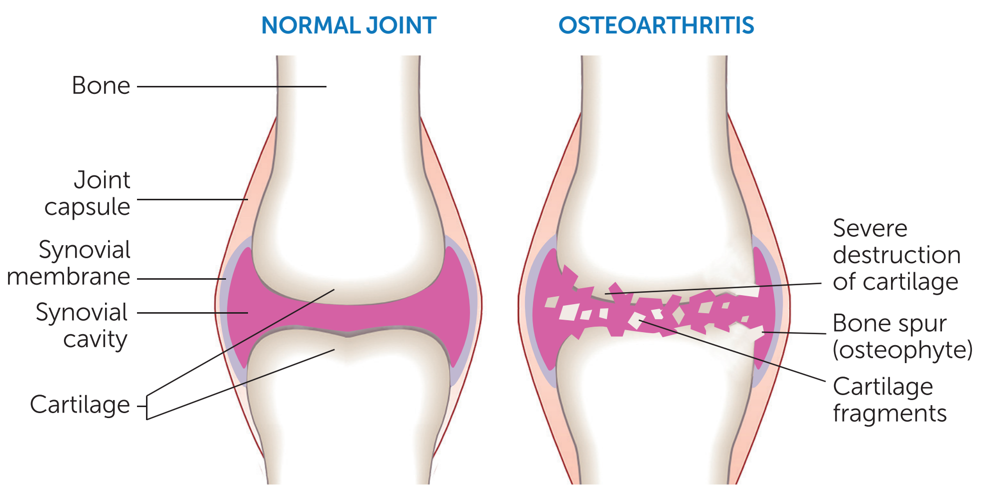


Table 3 Causes of osteoarthritis

• Mechanical factors, including those related to lifestyle
• Age
• Sex
• Genetics and heredity
• Obesity
• Endocrine diseases
• Metabolic diseases
• Inflammation

cartilage. After 11 weeks of immobilization, in fact, there is a decrease in glycosaminoglycans, which are important proteins in hyaline cartilage.

Recently, it has also been shown that the contralateral joint that is not immobilized also presents arthritic degeneration. This is very important because if a limb is immobilized for various reasons, such as bed rest due to a fracture or for an arthroprosthesis, the contralateral limb will also suffer damage due to non-use, which requires proper rehabilitation or pharmacological support.

Can osteoarthritis be cured?

Osteoarthritis can be treated or mitigated through surgery, oral medications, or infiltration of therapeutic substances such as hyaluronic acid, but if we want to have pain-free joints that age well, it is essential to move in a healthy way throughout life. Exercise and an active lifestyle are considered a real medicine today because they help prevent joint problems by slowing the aging of cartilage and ligaments.

In addition to the hyaline cartilage, other anatomical structures within a joint also suffer damage if they are not used properly. In fact, when a limb is immobilized, an important inflammatory process occurs that causes irreversible microscopic alterations of the affected joint and leads to loss of mobility within a few weeks.

THE EFFECTS OF MOVEMENT ON THE CIRCULATORY SYSTEM

The blood circulates in a system of blood vessels called arteries, veins, or capillaries depending on their specific function.

The heart, a hollow muscle located in the center of the chest cavity, acts as a pump to transport arterial blood (rich in oxygen) to all the tissues of the body through the **arteries**, supplying the cells with the various energy substrates (oxygen, fats, and sugars) [**figure 12**].

The venous blood (loaded with carbon dioxide) returns from the periphery to the heart through the **veins**.

This transportation of arterial blood from the heart to the periphery and the return of venous blood to the heart is called **systemic circulation**, while the transportation of venous blood from the heart to the lungs and of re-oxygenated blood back to the heart is called **pulmonary circulation** [**figure 13**].

Figure 12 The heart

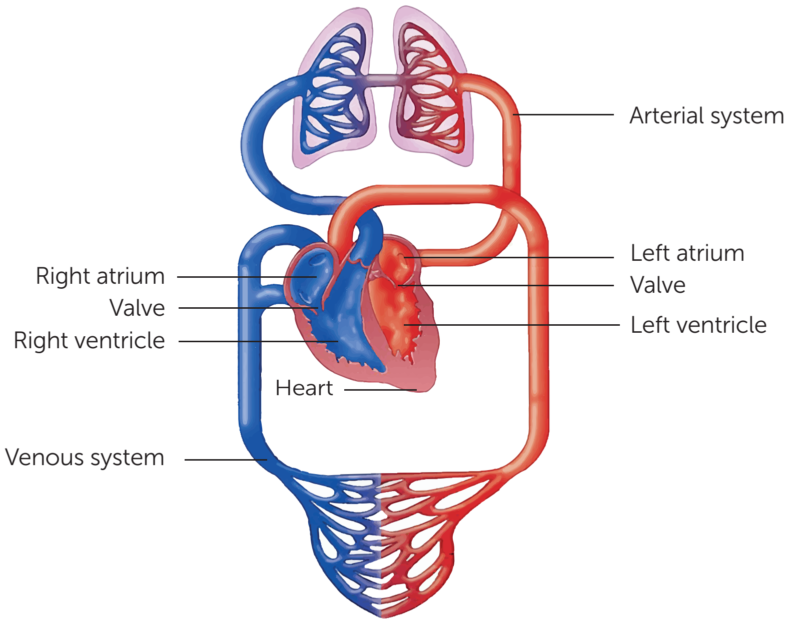
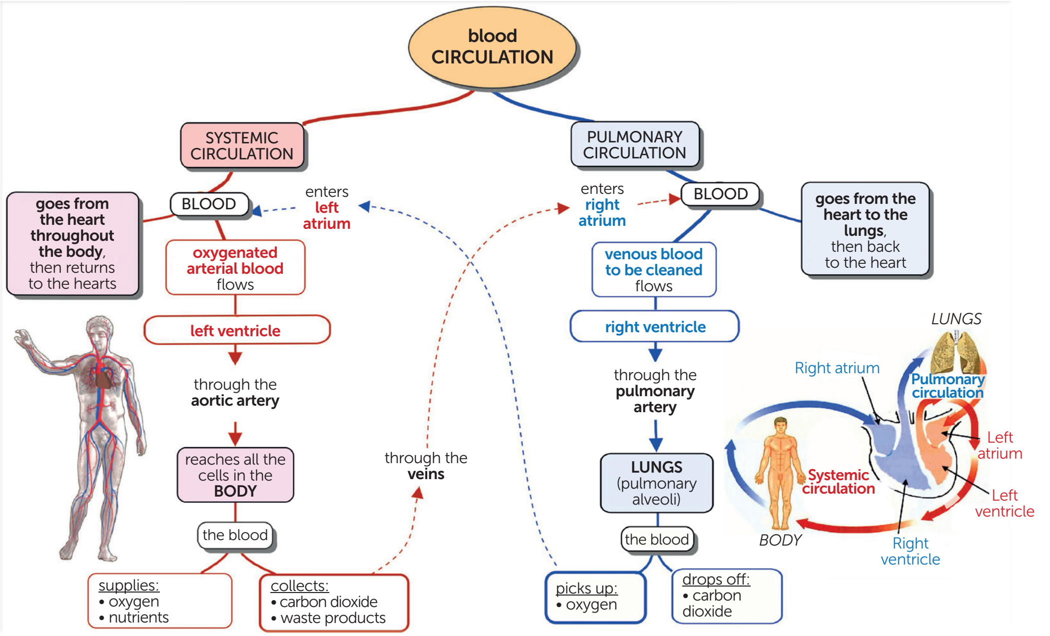


Figure 13 Systemic and pulmonary circulation



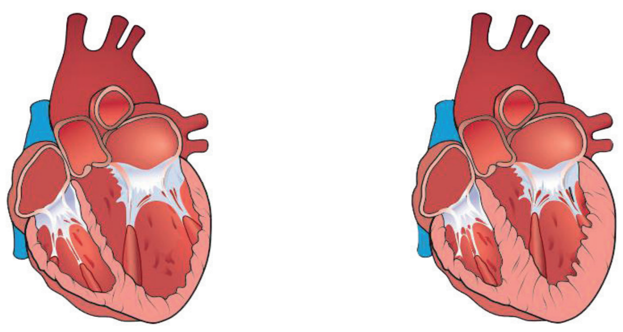
During physical activity, the muscles need more energy sources, so the heart increases its rate of contraction from 70-75 beats per minute to up to 200; consequently, the intensity of the blood flow increases, enabling a better supply of energy sources to the muscles.

Training, especially if it is intense, forces the whole body to undergo morphological and functional changes, called **adaptations**. These can be central or peripheral.

Central adaptations affect the heart and pulmonary circulation:

- hypertrophy of the myocardium (increase in the volume of the internal cavities: the atria, the ventricles, and the muscle walls themselves thicken. This condition is called "athlete's heart" [**figure 14**];
- increased systolic output (the amount of blood expelled at each contraction of the heart): by increasing the volume of the internal cavities and the muscle strength, the heart can pump a greater amount of blood with each systole;

Figure 14 Normal heart and athlete’s heart



- increased cardiac output (the amount of blood pumped in one minute);
- increased heart rate (the number of beats per minute) during physical activity. However, it should be remembered that highly trained individuals will have a lower number of beats per minute, because their hearts are able to pump a greater amount of blood;
- reduced resting heart rate (bradycardia). This is one of the effects that is easiest to verify, but it is only achieved through consistent and prolonged training. Great athletes, especially those who do prolonged endurance races, have a heart rate of 36-40 beats per minute;
- reduced recovery time after exertion. Trained individuals return to their resting heart rate faster than sedentary individuals.

Peripheral adaptations affect the blood vessels, arteries, veins, and capillaries:

- increased number of capillaries in the heart; the hearts of people who train have more capillaries than those of people who lead a sedentary lifestyle, to ensure a better supply of blood and nutrients to the heart;
- increased number of capillaries in the muscles; the opening of new blood supply channels is important to transport more nutrients to the muscles and to eliminate waste products produced by muscle contractions.

Why do people who don't do physical activity experience pain in their side (stitches) during sudden intense exercise?

When a person who normally leads a sedentary life suddenly performs particularly intense exercise, they often feel a **pain in their side**, known as a "stitch". The reason for this is that, being untrained, they have not developed the extensive collateral circulation that supplies the muscles with blood and therefore the need for bloody supply and oxygenation is met by organs such as the intestines, stomach, liver, and spleen, which divert blood to the muscles.

The importance of physical activity to preserve the elasticity of the heart walls, the trophism of the blood vessels, and good oxygenation of all tissues is therefore evident.

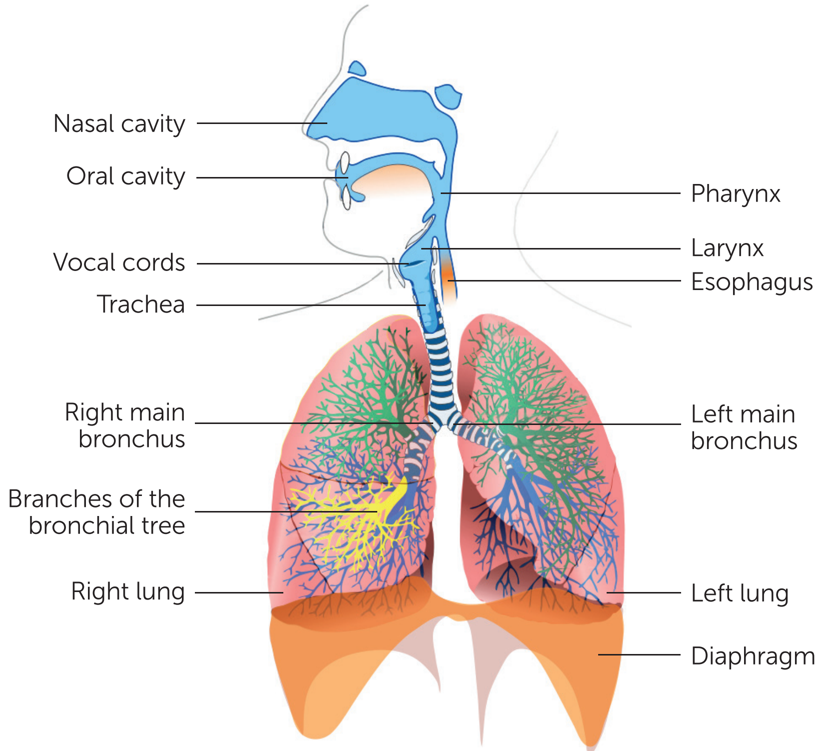
THE EFFECTS OF MOVEMENT ON THE RESPIRATORY SYSTEM

Thanks to the functioning of its organs, the respiratory system enables the continuous supply of oxygen (O_2) to the body's cells and the elimination of carbon dioxide (CO_2).

We breathe in air, which is rich in oxygen (O_2), through our **nose** or **mouth**; this air then travels through the respiratory tract (**trachea**, **bronchi**) and reaches the **lungs**, which have a crucial task [**figure 15**]. Here, in the pulmonary alveoli, the red blood cells present in the blood capture the oxygen (O_2) from the inhaled air and transport it to the tissues by means of hemoglobin. The cells that make up our tissues thus obtain the oxygen (O_2) they need for cellular respiration and release carbon dioxide (CO_2) as a waste product. Once it returns to the lungs, the blood will get rid of this waste to start a new cycle [**figure 16**].

During exercise, the need for oxygen (O_2) increases significantly, because more is required and used by the muscles when they undergo exertion. Oxygen (O_2) consumption during a demanding task can increase by up to 15-20 times compared to consumption in resting conditions.

Figure 15 The respiratory system



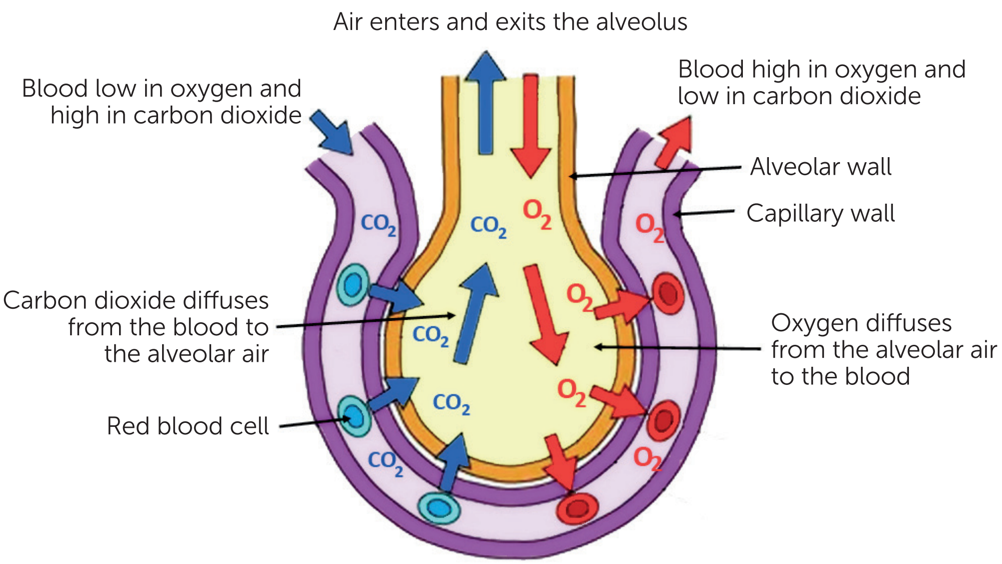
This is why the **respiratory rate increases** during physical activity, followed by the symptom of fatigue, which manifests as shortness of breath (being "out of breath"). This can be remedied by learning to breathe better, that is, to take full breaths, expanding the rib cage as much as possible.

Why do you breathe faster during exercise?

Making a habit of movement:

- increases the capacity for recovery: following exertion, trained individuals are able to return to their normal respiratory rate more easily;
- improves respiratory mechanics: physical exercise increases the power of the respiratory muscles, in particular the diaphragm, and improves the efficiency of their movements;

Figure 16 The oxygen-carbon dioxide exchange



- increases vital capacity, i.e., the amount of air (measured in liters with a spirometer) that can be exhaled after a maximum inhalation;
- increases safe apnea time, that is, how long a person can voluntarily hold their breath, which is very important in underwater swimming and diving;
- reduces the respiratory rate, because more air can be drawn in with each inhalation.

THE EFFECTS OF MOVEMENT ON PSYCHOLOGICAL AND EMOTIONAL WELL-BEING

Physical activity, if done frequently, also has a significant impact on people's well-being.

In fact, sport not only allows you to add years to your life, but also increases your **quality** of life over the years. Since 1992, the International Society of Sport Psychology (ISSP) has established that physical activity leads to both short-term and long-term psychological improvements and produces **psychological well-being**. In particular, the personal benefits derived from physical activity are:

- increased confidence and mindfulness;
- improved mood with reduced depression and anxiety;
- a positive change in self-perception;
- increased energy and ability to cope with daily activities.

The mood-elevating and anxiety-reducing effects induced by exercise seem to be linked to the release of **β-endorphins** (a class of substances naturally present in our body that act as neurotransmitters, function as **natural pain-killers**, and reduce depression and stress). Specifically, the release of endorphins seems to induce a **euphoric state** (more akin to a **sense of lightness and relief**) and a reduction in pain. Just consider that ten minutes of intense physical activity can increase endorphin levels for an hour [figure 17].

Each type of exercise has important effects on the production of endorphins and certain neurotransmitters, chemicals also present in our body, which are

Figure 17 The effects of physical activity on the brain

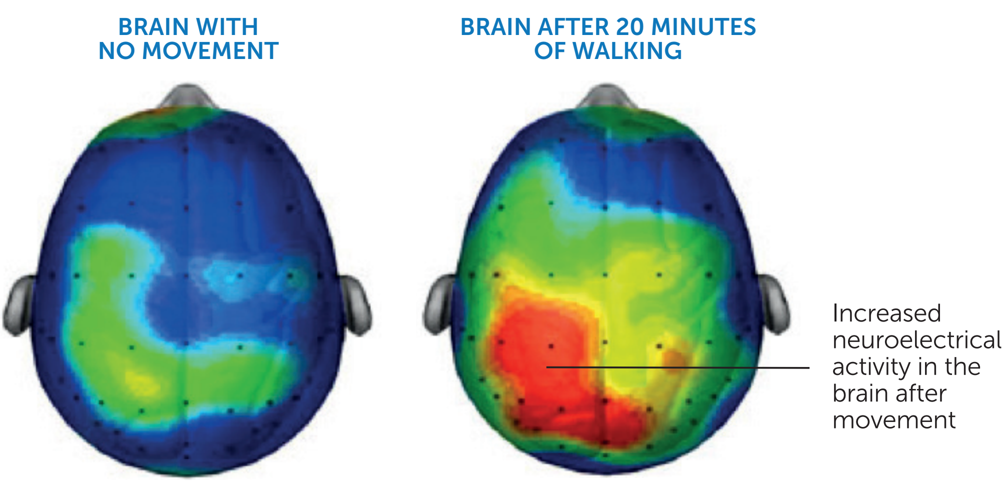


Figure 18 The main neurotransmitters

released by the brain and are involved in communication between nerve cells [**figure 18**].

Alongside endorphins, another factor that has important effects on mood and anxiety is what's known as **BDNF** (Brain Derived Neurotrophic Factor). In fact, it seems that a reduction in the **levels of this neurotrophin in the hippocampus** is correlated with depressive and anxious states. Exercise, especially if done regularly, stimulates the brain to increase the production of BDNF, which is essential for a more positive outlook on life.

THE DIFFERENT TYPES OF PHYSICAL ACTIVITY

Referring to the *Global Recommendations on Physical Activity for Health* published by the WHO in 2010, which we discussed earlier, we can distinguish between three age groups, which different types of activities and amounts of time are associated with:

Is the physical exercise we need to stay fit the same for all ages?

- children and adolescents (ages 5 to 17);
- adults (ages 18 to 64);
- adults/the elderly (age 65 and older).

Before examining the activities recommended by WHO, it is important to distinguish between **moderate-intensity** and **vigorous-intensity activities**.

The former are normally characterized by a higher energy expenditure than at rest and the classic example is brisk walking. Vigorous-intensity activity, on the other hand, results in an even higher energy expenditure. At this intensity, it normally becomes more difficult to hold a conversation, so much so that you cannot say more than a few words without having to catch your breath.

CHILDREN AND ADOLESCENTS

Physical activity for children and adolescents includes play, structured exercise, and sport and should be predominantly aerobic in nature, beginning gradually and progressively increasing in duration, frequency, and intensity.

For this age group, the WHO recommends doing at least **60 minutes of daily physical activity of moderate to vigorous intensity**, as well as exercises to strengthen the musculoskeletal system at least 3 times a week. The daily goal of 60 minutes of physical activity can be achieved in multiple shorter sessions (e.g., two 30-minute sessions).

It is important that the physical activity is aerobic, such as hiking, walking, martial arts like karate, volleyball, swimming, running, tennis, gymnastics, jump rope, and playing tag.

◎ ADULTS

The WHO recommends doing **a minimum of 150 minutes of moderate-intensity aerobic physical activity a week** or a minimum of 75 minutes of vigorous activity, plus exercises to strengthen the major muscle groups 2 or more times a week.

In addition to aerobic activity, adults should perform strength training exercises, such as squats, push-ups, and appropriate exercises with weights or gym machines for a minimum of two sessions per week, performed on non-consecutive days and structured in such a way as to involve most muscle groups.

Inactive and sedentary people are in the riskiest condition. It is therefore advisable for all adults to frequently break up periods in which they are sitting or reclining, ideally at least every 30 minutes, with even short periods (2-3 minutes) of walking, bodyweight exercises on the spot (for example, squats, even simply by repeatedly getting up from a chair or sofa), or periodically alternating between sitting and standing (for example, every 30 minutes).

◎ ELDERLY PEOPLE

According to the WHO, to improve their cardiorespiratory and muscular health and reduce their risk of chronic non-communicable diseases, depression, and cognitive decline, adults over 65 years of age should do:

- at least 150 minutes per week of moderate-intensity **aerobic** physical activity;
- or at least 75 minutes of vigorous aerobic physical activity each week;
- or an equivalent combination of moderate-intensity and vigorous activities.

It is also recommended to combine this with exercises to strengthen the major muscle groups two or more times a week and activities to improve balance and prevent falls three or more times a week for people with reduced mobility. The recommended activity levels can be accumulated by exercising for relatively short intervals of time.

It is essential to encourage older people to make physical activity part of their daily lives, for example by taking long brisk walks rather than using a private means of transport. You can also maintain an adequate level of activity with the normal tasks of daily life (such as shopping, cleaning, and preparing meals).

For older adults who intend to undertake regular physical activity, it is advisable to start gradually and it is necessary to carry out a careful preliminary evaluation, possibly including filling out specific questionnaires, both to identify individuals with chronic diseases or with symptoms associated with the presence of pathologies and to recommend an appropriate and personalized exercise program.

The recommendations of the WHO have been adopted in Switzerland through a document published by the aforementioned Federal Office of Sport, whose guidelines for the different age groups are shown in **figure 19**.

Figure 19 Recommendations for children and adolescents, adults, and the elderly

Source: www.hepa.ch

THE DIFFERENCES BETWEEN DIFFERENT SPORTS

Nowadays, there are numerous different types of sports and various criteria by which they can be classified. One of the most well-validated ways of classifying them distinguishes between:

- **endurance** sports: athletics, middle-distance and long-distance running, swimming, rowing, triathlon, finswimming, canoeing and kayaking, modern pentathlon, cycling, roller skating, and jogging;
- **power** sports: sprint swimming, alpine and grass skiing, athletics (sprinting, hurdling, throwing, combined track and field events), sprint and track cycling, weightlifting, golf, sport climbing;
- **individual combat** sports and **individual games**: wrestling, judo, fencing, karate, tennis, squash, boxing, taekwondo, badminton, and other racket sports;
- **team** sports: baseball, softball, football, water polo, hockey, volleyball, basketball, handball, American football, and rugby;
- **technical-combinatory disciplines**: horse riding, water skiing and sailing, sport fishing, diving and synchronized swimming, precision skating, ice skating and figure skating, artistic and rhythmic gymnastics, dance, billiards, bowls, and golf;
- **accuracy and motor** sports: karting, motorcycling, skeet shooting, motor racing and motorboating, timekeeping, target shooting, and archery.

There are numerous differences between the various types of sports, in terms of both technique and intensity; in fact, there are, for example, sports that are less intense but require more endurance and sports that involve a lot of power applied in short time segments.

STUDIES ON SEDENTARY LIFESTYLES

As we mentioned earlier, scientists have developed many models to better study certain specific aspects of sedentary lifestyles.

NASA and the European Space Agency have been studying astronauts returning from space flights since the 1970s. We now know that **spaceflight** induces bone fragility and increases bone resorption and sarcopenia, that is, **loss of muscle mass and strength**. These processes are normally related to aging, but in astronauts they occur prematurely due to the long periods spent in the absence of gravity, where the mechanical load that stimulates the activity of osteocytes and skeletal muscles is lacking.

The **bone lost** during space travel is not regained 100% and, to avoid permanent complications, astronauts follow special rehabilitation programs based on specific exercises performed both in orbit and on their return to Earth.

CONCLUSIONS

Human beings need to be in constant movement. Staying still is dangerous and risks compromising both life expectancy and quality of life. In addition to this, combating a sedentary lifestyle also has a positive effect on our social life. As the document from the Federal Office of Sport reminds us: getting moving and meeting other people means helping to build the social fabric of a community and keep it alive. So now we know the positive effects of movement, all that's left for us to do is follow the recommendations scattered throughout this booklet and get moving in every sense of the word...

We'll finish this booklet all about the importance of movement by remembering the words of men who changed the world and who understood how important movement is in every sense of the word: figurative, biological, and philosophical.

Let him that would move the world first move himself (Socrates).

Mens sana in corpore sano (Juvenal, Satires, X, 356).

Life is like riding a bicycle. To keep your balance, you must keep moving (Albert Einstein).

There are no roots at our feet, they are made to move (David Le Breton).

Nothing is more revealing than movement (Marta Graham).

I move, therefore I am (Haruki Murakami).

And yet it moves (Galileo Galilei at the court of the Inquisition at the end of his renunciation of heliocentrism).

Our nature consists in motion; complete rest is death (Blaise Pascal).

Then all motion, of whatever nature, creates (Edgar Allan Poe).

Comes over one an absolute necessity to move. And what is more, to move in some particular direction. A double necessity then: to get on the move and to know whither (David Herbert Lawrence).

Move, live, don't think! (Luigi Pirandello).

Energy is always moving outwards or inwards. It can never stay still: if it were still, it would not be energy, but there is nothing that is not energy. So, everything is moving somehow (Osho Rajneesh).

A running athlete is a moving sculpture (Edwin Moses).

Consciousness is only possible through change; change is only possible through movement (Aldous Huxley).

Everything is in continuous movement above the Earth. Nothing stays in a constant, fixed form, and our affections, which attach themselves to external things, necessarily move on and change like those things (Domenico Cirillo).

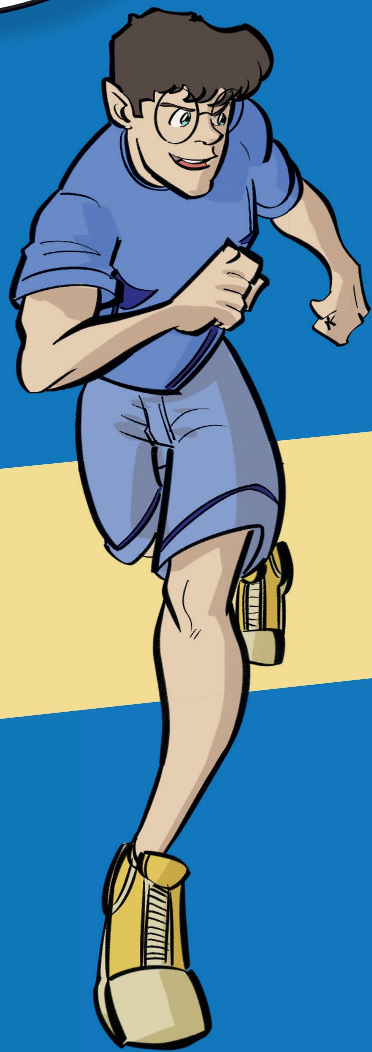
Darkness is still, but where does light go at such speed? (Mikhail Kuzmin).

There can be no transforming of darkness into light and of apathy into movement without emotion (Carl Gustav Jung).

Life is movement, movement is life (Andrew Taylor Still).

The Astronauts' Disease

PART TWO



TEXTS

By the students of class 3B of the Lugano 1 Middle School:

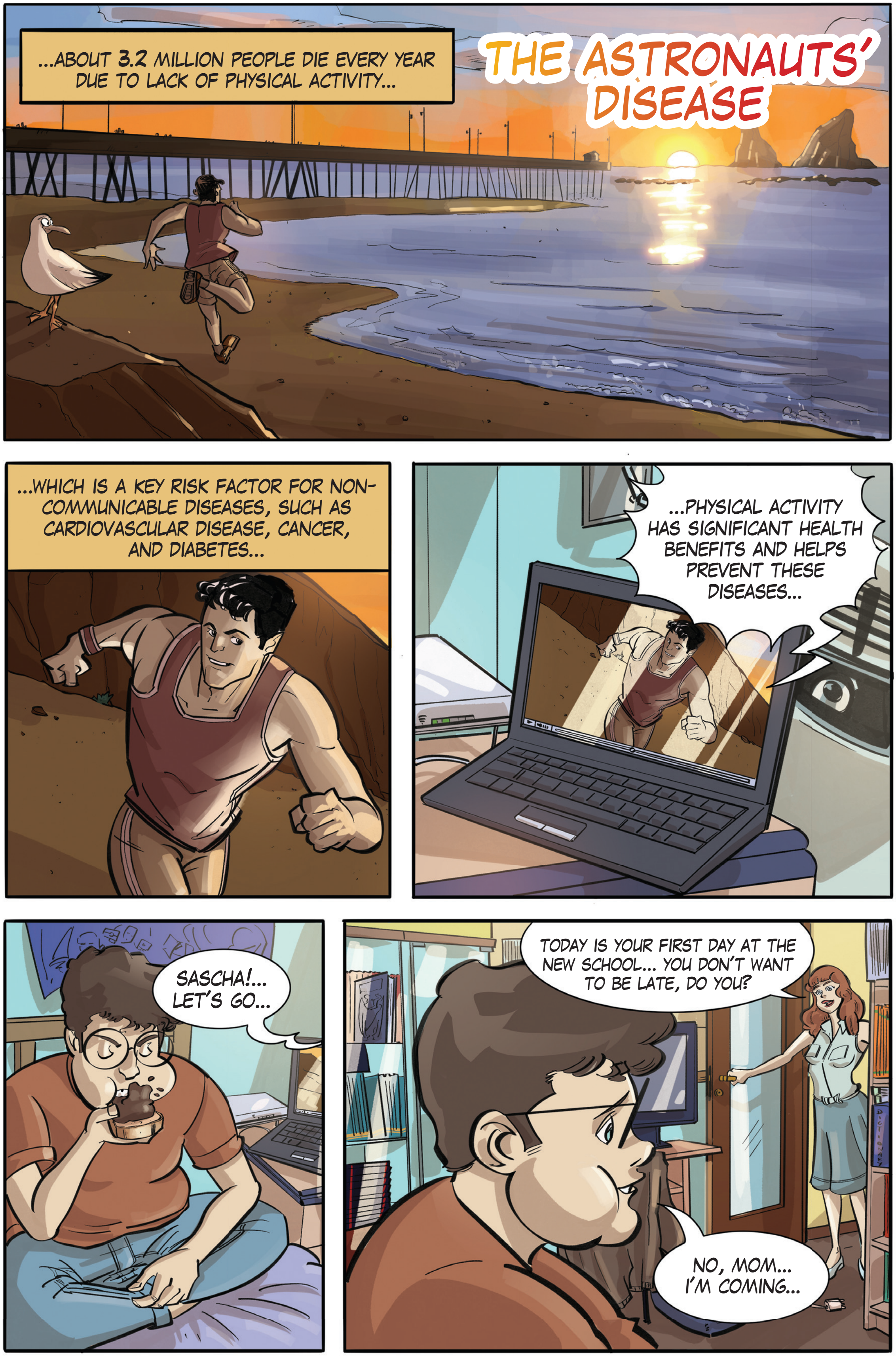
Tony Arnaboldi
Betiel Bahabelom
Anriel Casetto
Alexander Chefanov
Dilara Di Stefano
Giulia Donato
Matilda Immordino
Daniel Padraig Jenkinson
Kristina Kataya
Hazal Keles
Tommaso Marzagalli
Mariana Mau Pao Dos Santos
Boris Mohamed Milutinovic
Sosdar Hussein
Luca Montemarano
Noemi Pacchin
Sabrina Pinelli
Alexandra Radic
Alessandro Radwanska
Antonio Rea
Elisa Renggli
Lavinia Suciu

Under the coordination of the teacher:
Veronica Zgraggen (natural sciences teacher)

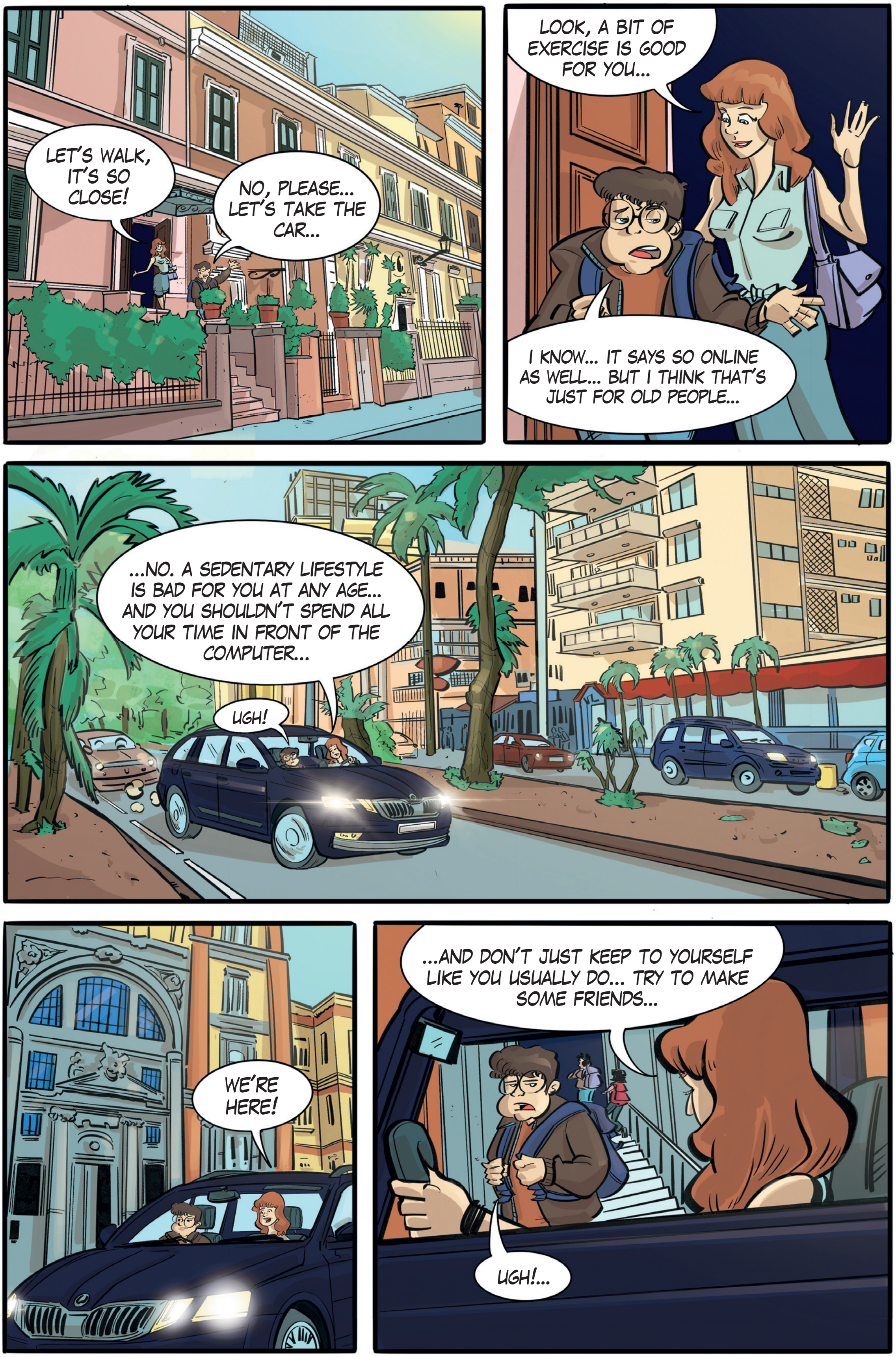
Lugano 1 Middle School
4 Viale C. Cattaneo - 6900 Lugano
Ticino - Switzerland
http://www.smlugano1.ti.ch/
decs-sm.lugano.centro@edu.ti.ch
Head Teacher: Fabio Cogoli

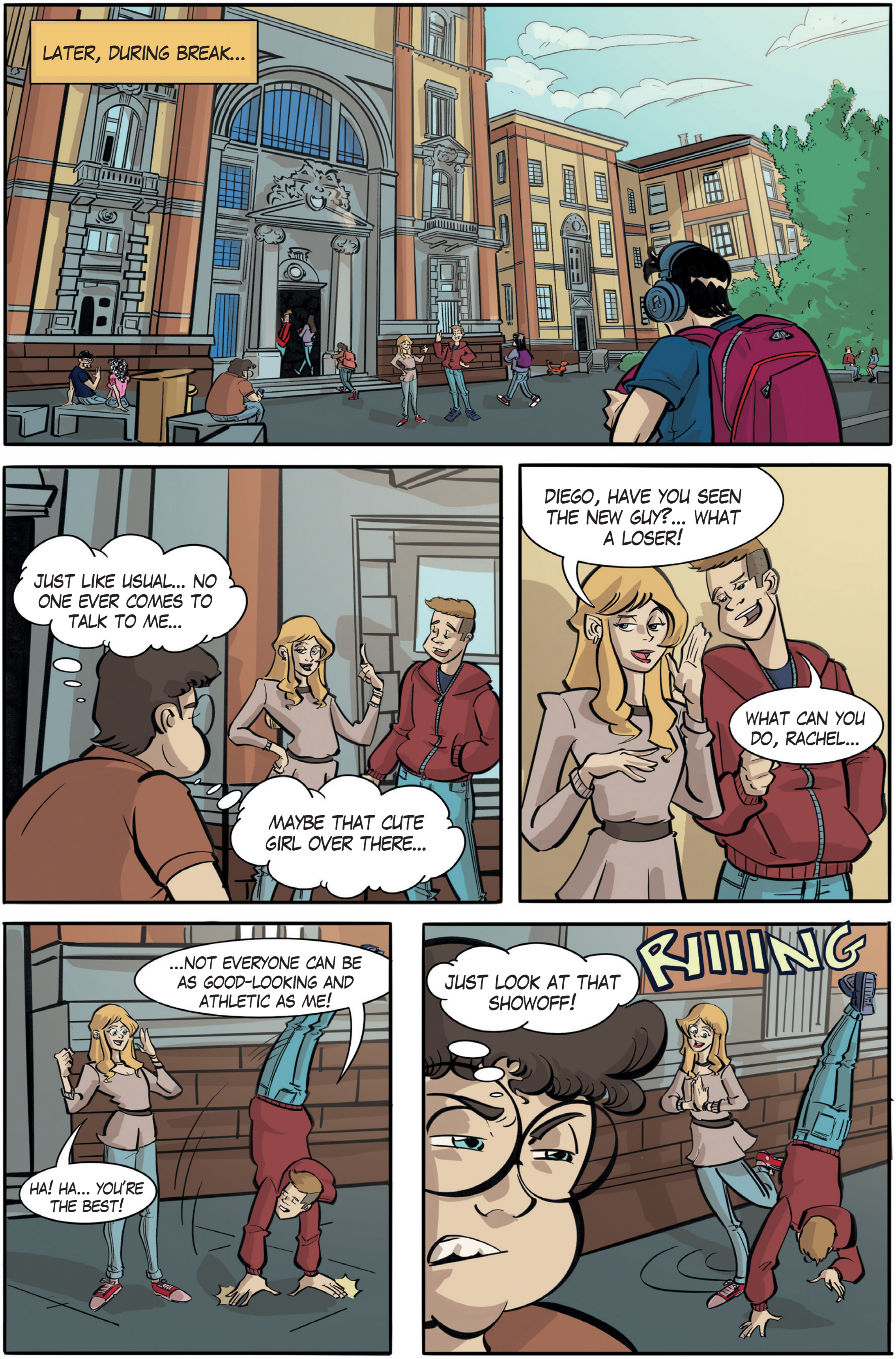
ILLUSTRATIONS

By Mirko Milone for the Scuola Romana dei Fumetti.



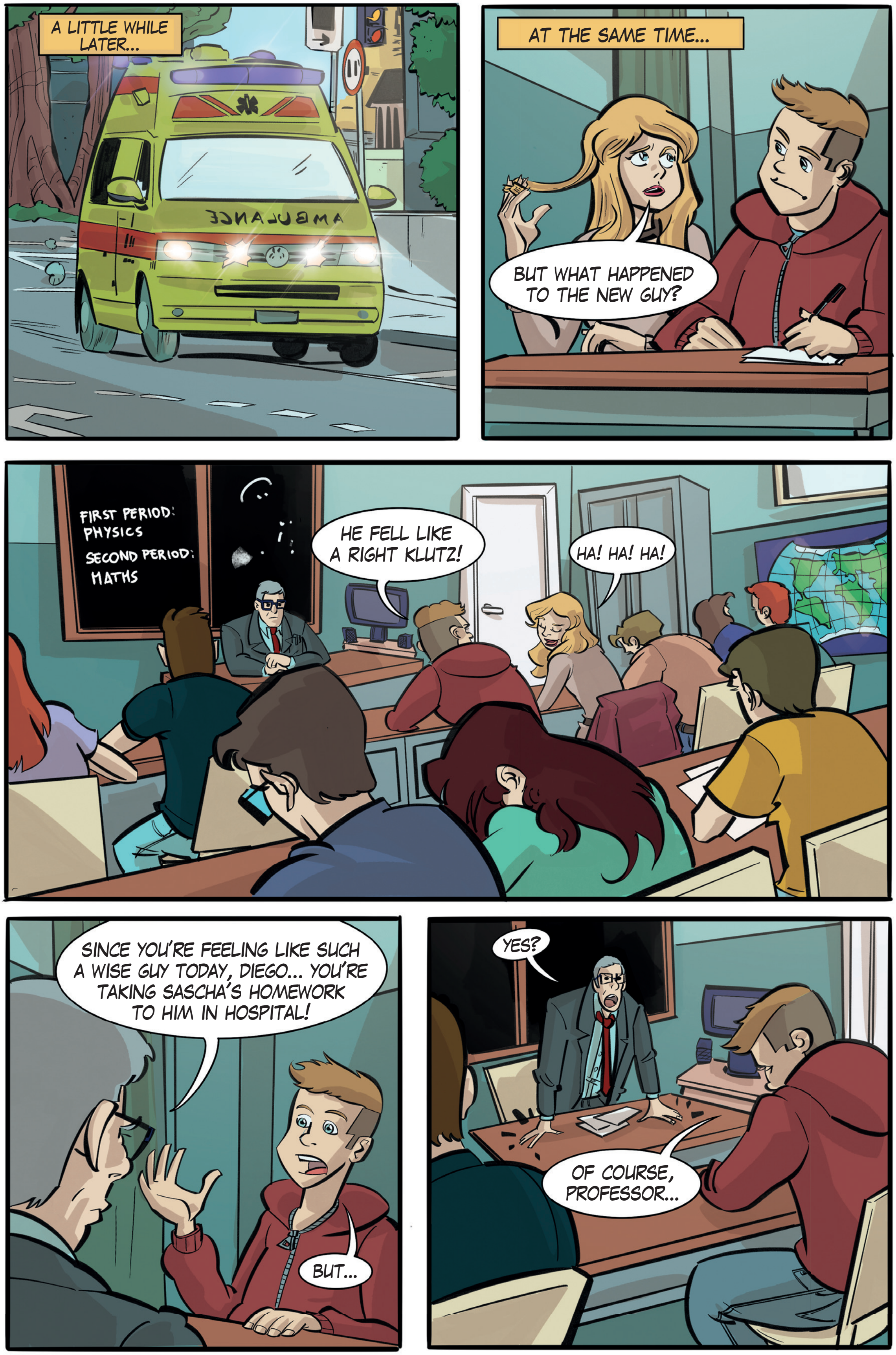
THE ASTRONAUTS' DISEASE
...ABOUT 3.2 MILLION PEOPLE DIE EVERY YEAR DUE TO LACK OF PHYSICAL ACTIVITY...
...WHICH IS A KEY RISK FACTOR FOR NON-COMMUNICABLE DISEASES, SUCH AS CARDIOVASCULAR DISEASE, CANCER, AND DIABETES...
...PHYSICAL ACTIVITY HAS SIGNIFICANT HEALTH BENEFITS AND HELPS PREVENT THESE DISEASES...
SASCHA!... LET'S GO...
TODAY IS YOUR FIRST DAY AT THE NEW SCHOOL... YOU DON'T WANT TO BE LATE, DO YOU?
NO, MOM... I'M COMING...

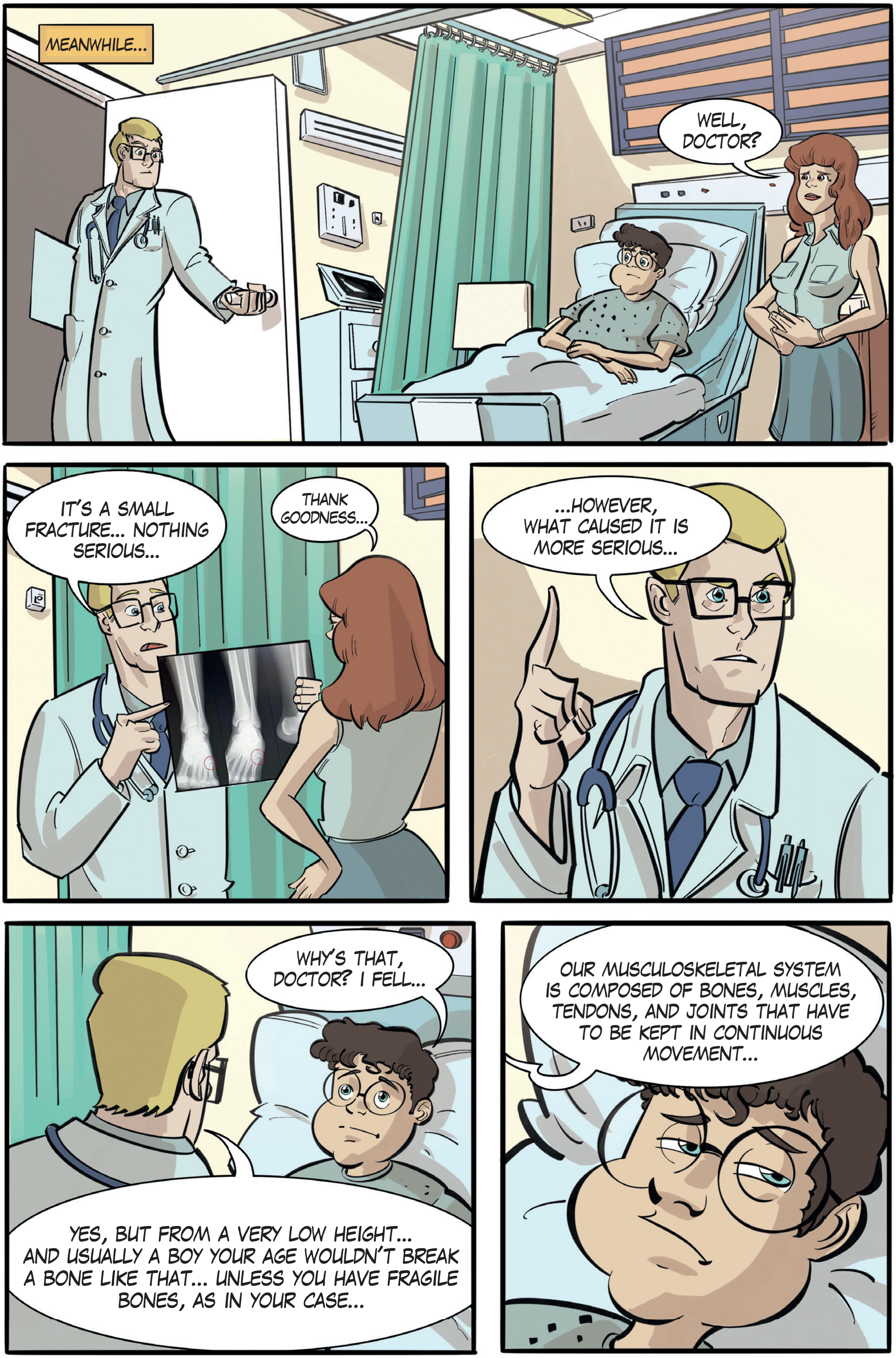

LET'S WALK, IT'S SO CLOSE!
NO, PLEASE... LET'S TAKE THE CAR...
LOOK, A BIT OF EXERCISE IS GOOD FOR YOU...
I KNOW... IT SAYS SO ONLINE AS WELL... BUT I THINK THAT'S JUST FOR OLD PEOPLE...
...NO. A SEDENTARY LIFESTYLE IS BAD FOR YOU AT ANY AGE... AND YOU SHOULDN'T SPEND ALL YOUR TIME IN FRONT OF THE COMPUTER...
UGH!
WE'RE HERE!
...AND DON'T JUST KEEP TO YOURSELF LIKE YOU USUALLY DO... TRY TO MAKE SOME FRIENDS...
UGH!...

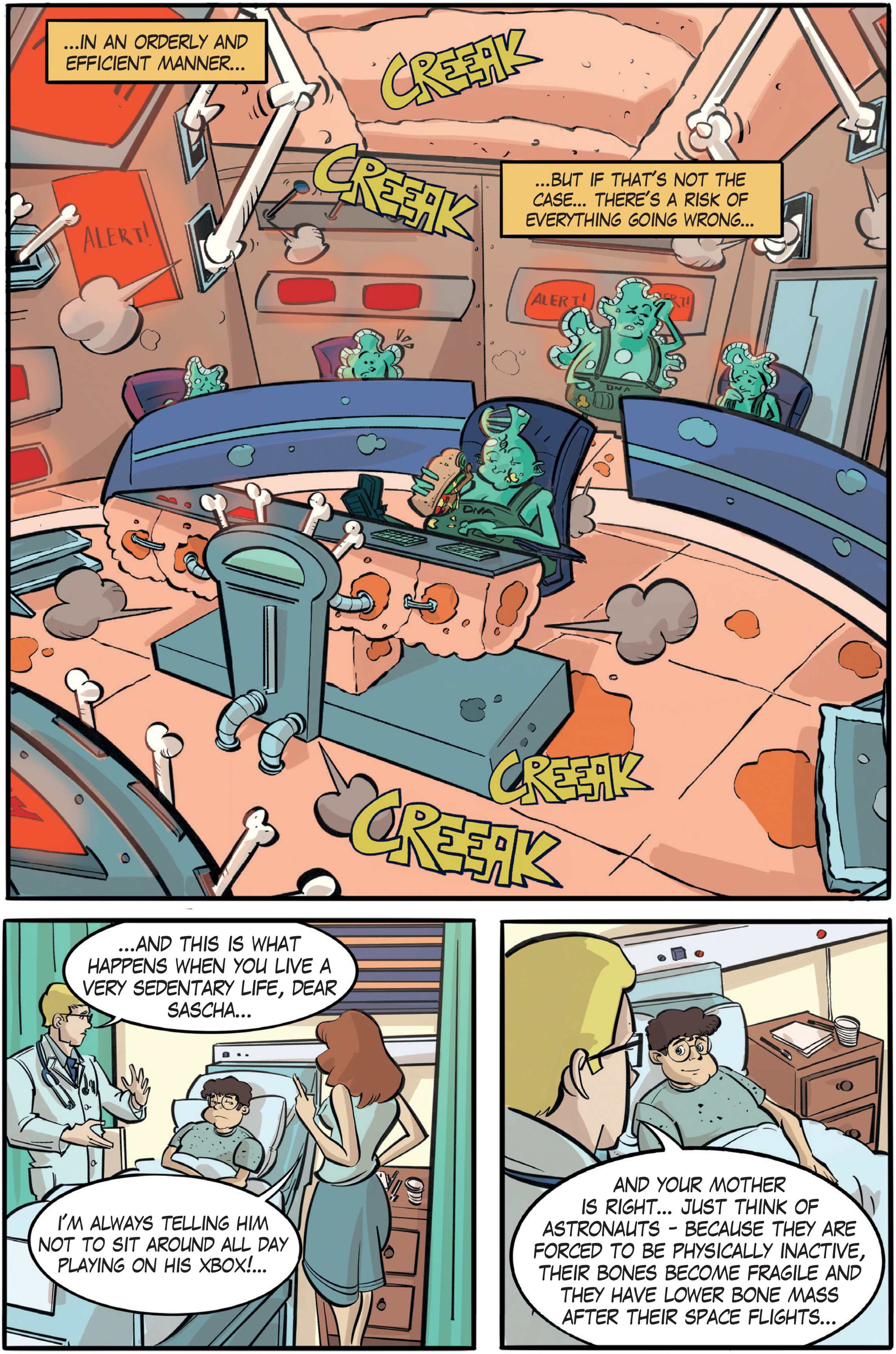

LATER, DURING BREAK...
JUST LIKE USUAL... NO ONE EVER COMES TO TALK TO ME...
MAYBE THAT CUTE GIRL OVER THERE...
DIEGO, HAVE YOU SEEN THE NEW GUY?... WHAT A LOSER!
WHAT CAN YOU DO, RACHEL...
...NOT EVERYONE CAN BE AS GOOD-LOOKING AND ATHLETIC AS ME!
HA! HA... YOU'RE THE BEST!
JUST LOOK AT THAT SHOWOFF!
RIIING

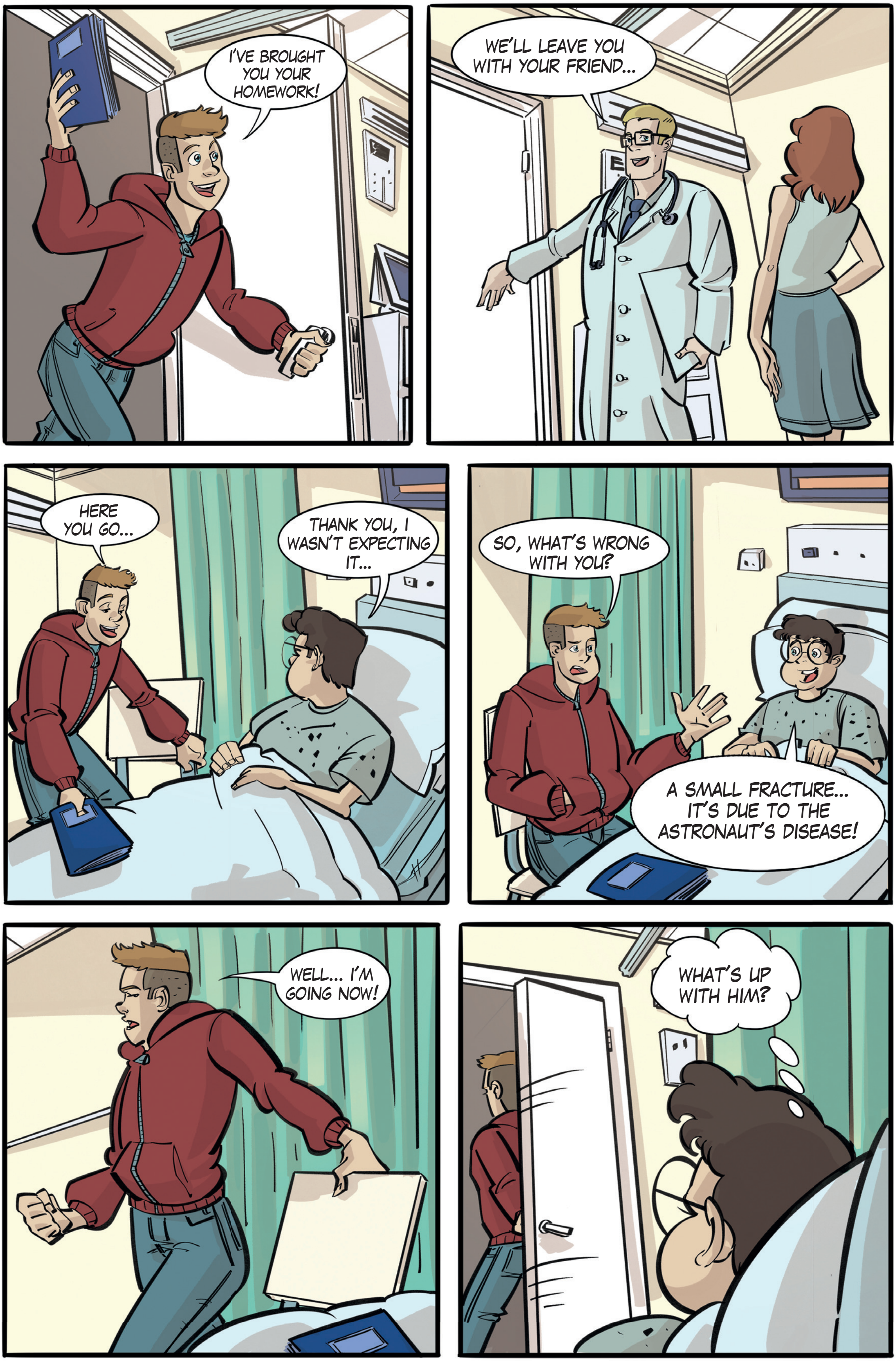

SHORTLY AFTER, IN THE SCHOOL GYM, DURING PHYSICAL EDUCATION...
NOW WE'RE GOING TO DO SOME CLIMBING...
BUT DO WE HAVE TO GO ALL THE WAY TO THE TOP?
THAT'S THE GOAL...
HA! HA! HA!
COME ON, GUYS... GET MOVING!

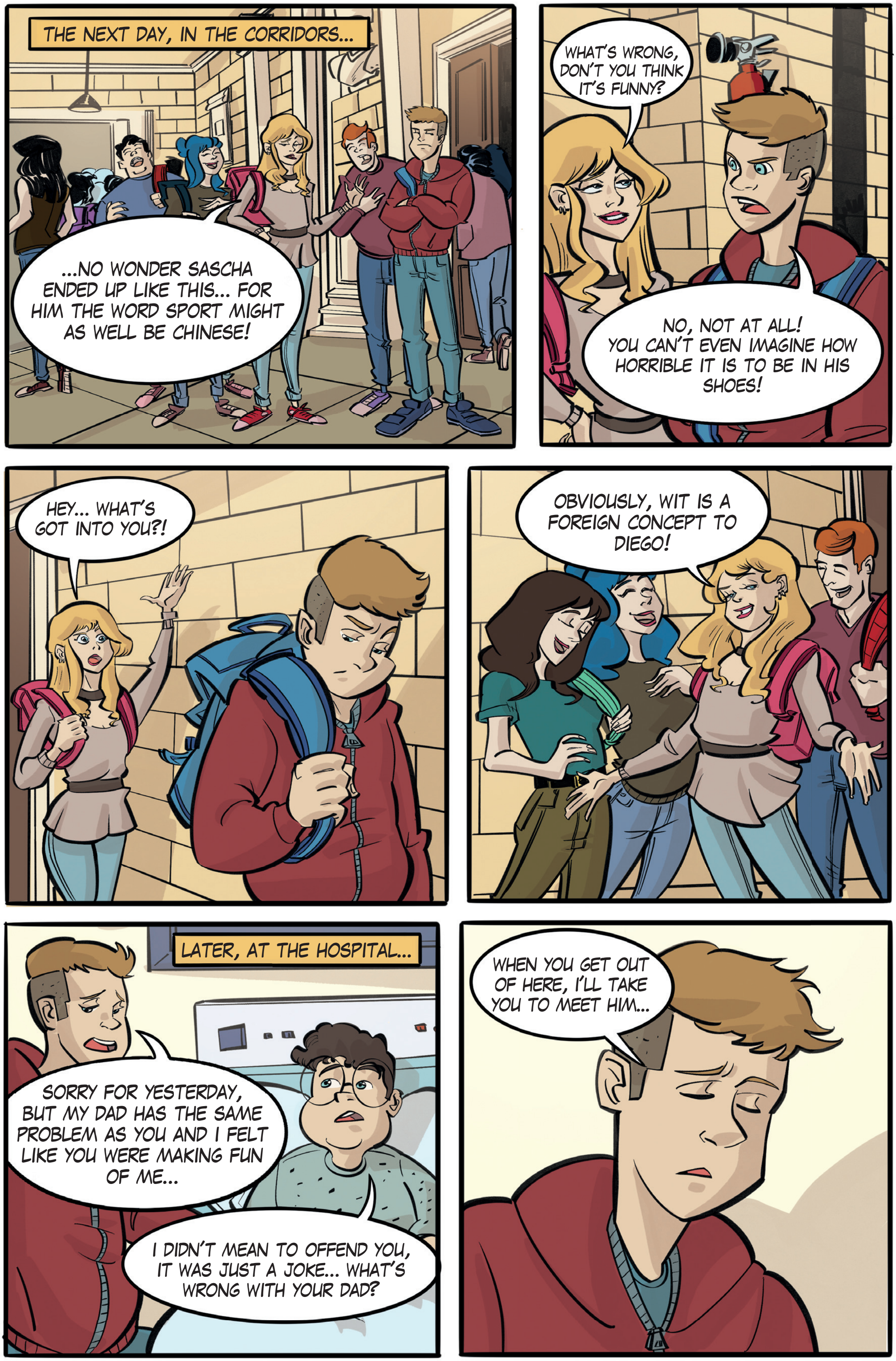

KEEP GOING... PUSH WITH YOUR LEGS AND PULL WITH YOUR ARMS AT THE SAME TIME!
COME ON, YOU CAN DO IT!
AHHH!
ARE YOU HURT?
YES...
HE'S PASSED OUT... LET'S CALL AN AMBULANCE... QUICKLY!

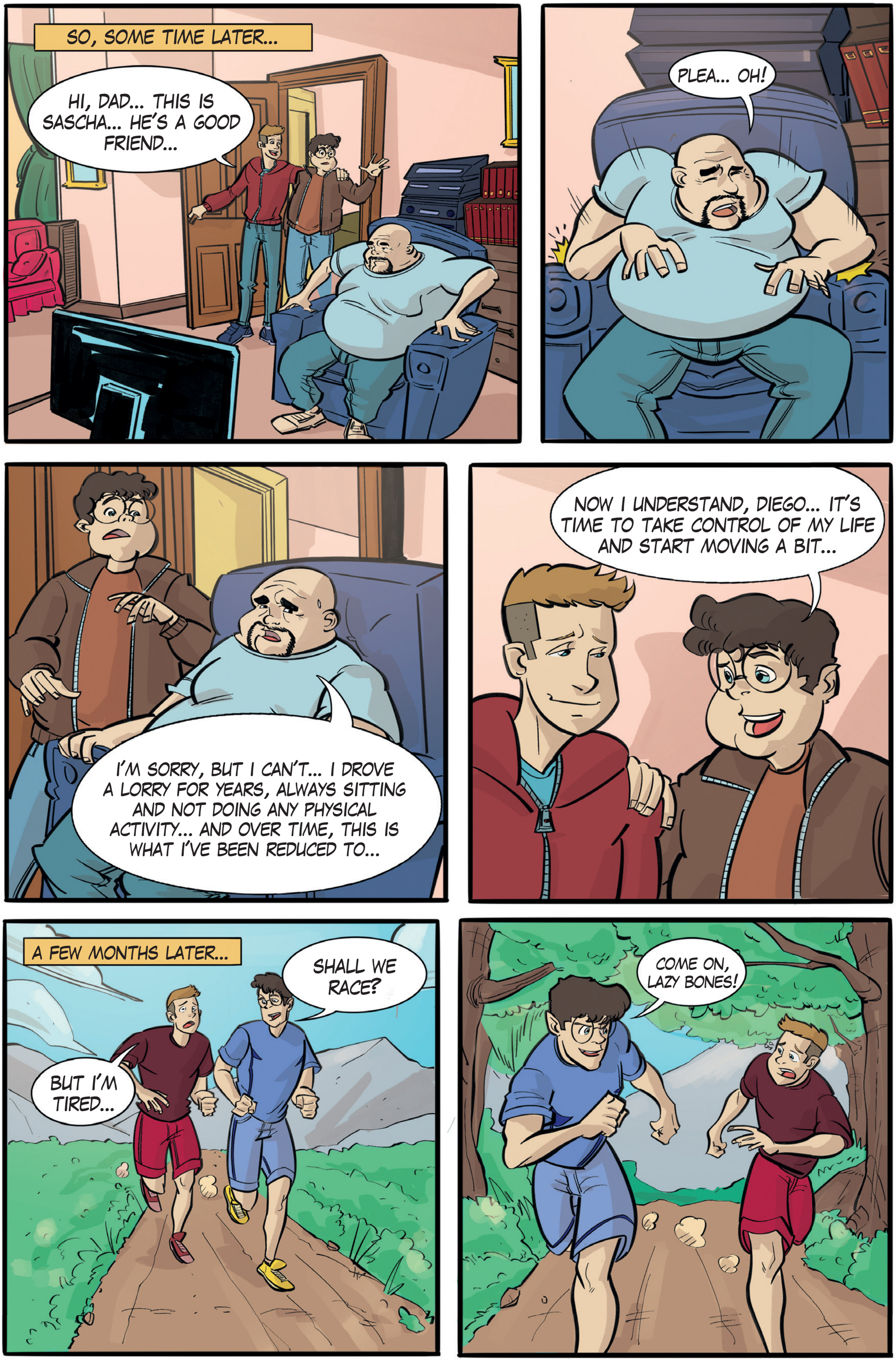

A LITTLE WHILE LATER...
AMBULANCE
AT THE SAME TIME...
BUT WHAT HAPPENED TO THE NEW GUY?
FIRST PERIOD: PHYSICS
SECOND PERIOD: MATHS
HE FELL LIKE A RIGHT KLUTZ!
HA! HA! HA!
SINCE YOU'RE FEELING LIKE SUCH A WISE GUY TODAY, DIEGO... YOU'RE TAKING SASCHA'S HOMEWORK TO HIM IN HOSPITAL!
BUT...
YES?
OF COURSE, PROFESSOR...

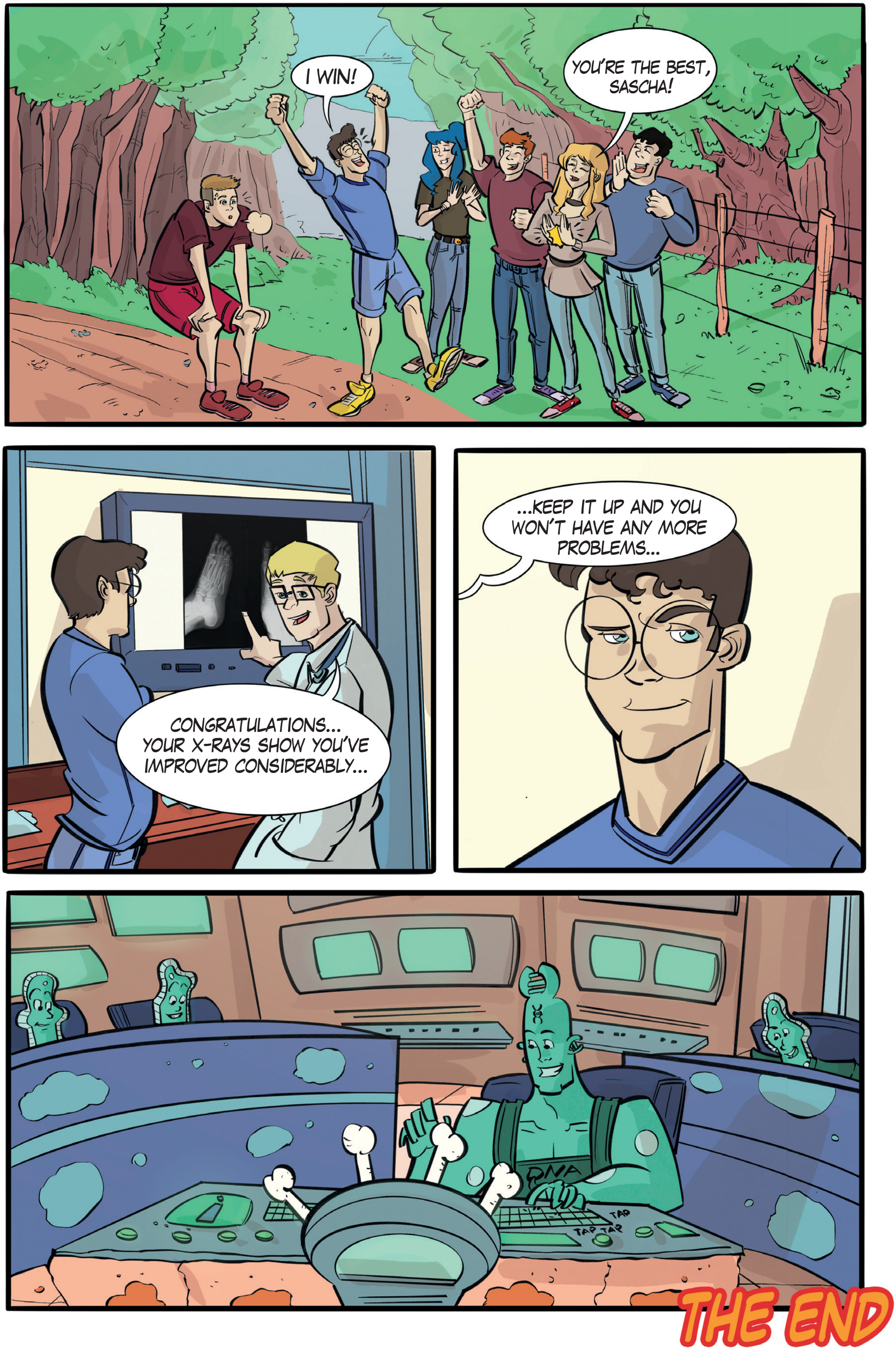

MEANWHILE...
WELL, DOCTOR?
IT'S A SMALL FRACTURE... NOTHING SERIOUS...
THANK GOODNESS...
...HOWEVER, WHAT CAUSED IT IS MORE SERIOUS...
WHY'S THAT, DOCTOR? I FELL...
YES, BUT FROM A VERY LOW HEIGHT... AND USUALLY A BOY YOUR AGE WOULDN'T BREAK A BONE LIKE THAT... UNLESS YOU HAVE FRAGILE BONES, AS IN YOUR CASE...
OUR MUSCULOSKELETAL SYSTEM IS COMPOSED OF BONES, MUSCLES, TENDONS, AND JOINTS THAT HAVE TO BE KEPT IN CONTINUOUS MOVEMENT...


...IN AN ORDERLY AND EFFICIENT MANNER...
CREEAK
CREEAK
ALERT!
...BUT IF THAT'S NOT THE CASE... THERE'S A RISK OF EVERYTHING GOING WRONG...
ALERT!
DNA
DNA
CREEAK
CREEAK
...AND THIS IS WHAT HAPPENS WHEN YOU LIVE A VERY SEDENTARY LIFE, DEAR SASCHA...
I'M ALWAYS TELLING HIM NOT TO SIT AROUND ALL DAY PLAYING ON HIS XBOX!...
AND YOUR MOTHER IS RIGHT... JUST THINK OF ASTRONAUTS - BECAUSE THEY ARE FORCED TO BE PHYSICALLY INACTIVE, THEIR BONES BECOME FRAGILE AND THEY HAVE LOWER BONE MASS AFTER THEIR SPACE FLIGHTS...


I'VE BROUGHT YOU YOUR HOMEWORK!
WE'LL LEAVE YOU WITH YOUR FRIEND...
HERE YOU GO...
THANK YOU, I WASN'T EXPECTING IT...
SO, WHAT'S WRONG WITH YOU?
A SMALL FRACTURE... IT'S DUE TO THE ASTRONAUT'S DISEASE!
WELL... I'M GOING NOW!
WHAT'S UP WITH HIM?


THE NEXT DAY, IN THE CORRIDORS...
...NO WONDER SASCHA ENDED UP LIKE THIS... FOR HIM THE WORD SPORT MIGHT AS WELL BE CHINESE!
WHAT'S WRONG, DON'T YOU THINK IT'S FUNNY?
NO, NOT AT ALL! YOU CAN'T EVEN IMAGINE HOW HORRIBLE IT IS TO BE IN HIS SHOES!
HEY... WHAT'S GOT INTO YOU?!
OBVIOUSLY, WIT IS A FOREIGN CONCEPT TO DIEGO!
LATER, AT THE HOSPITAL...
SORRY FOR YESTERDAY, BUT MY DAD HAS THE SAME PROBLEM AS YOU AND I FELT LIKE YOU WERE MAKING FUN OF ME...
I DIDN'T MEAN TO OFFEND YOU, IT WAS JUST A JOKE... WHAT'S WRONG WITH YOUR DAD?
WHEN YOU GET OUT OF HERE, I'LL TAKE YOU TO MEET HIM...


SO, SOME TIME LATER...
HI, DAD... THIS IS SASCHA... HE'S A GOOD FRIEND...
PLEA... OH!
I'M SORRY, BUT I CAN'T... I DROVE A LORRY FOR YEARS, ALWAYS SITTING AND NOT DOING ANY PHYSICAL ACTIVITY... AND OVER TIME, THIS IS WHAT I'VE BEEN REDUCED TO...
NOW I UNDERSTAND, DIEGO... IT'S TIME TO TAKE CONTROL OF MY LIFE AND START MOVING A BIT...
A FEW MONTHS LATER...
SHALL WE RACE?
BUT I'M TIRED...
COME ON, LAZY BONES!


I WIN!
YOU'RE THE BEST, SASCHA!
CONGRATULATIONS... YOUR X-RAYS SHOW YOU'VE IMPROVED CONSIDERABLY...
...KEEP IT UP AND YOU WON'T HAVE ANY MORE PROBLEMS...
DNA
TAP
TAP TAP
THE END

GLOSSARY

Achilles tendon The Achilles tendon, or calcaneal tendon, originates from the triceps surae muscle (formed by the two-headed gastrocnemius and the soleus) and inserts on the calcaneus bone. The name "Achilles' heel" comes from Greek mythology: when Achilles was born, the nereid Thetis was given a prophecy that her son would die during the Trojan conflict; she then immersed him in the river Styx to protect his body from danger. However, she held him by the tendon, meaning that the water did not touch this part of his body, so it remained vulnerable. During the Trojan War, Achilles was struck on that tendon by a poisoned arrow, which killed him. It is the largest and strongest tendon in the body and is about 15 cm long.

Aerobic activity This is a low-intensity, long-duration activity. It enables you to "burn" stored fat, not just the sugars present in the blood and muscles. Burning fat also means lowering cholesterol and triglyceride levels.

Anaerobic activity This is an activity relying on power, in which you exert an intense effort, technically called a maximum, in a short period of time. It is characterized by sudden contractions of the muscles and helps to increase muscle mass and burn off sugars as energy.

Arteries The arteries are blood vessels (3 types in total: arteries, arterioles, and arterial capillaries) that branch out from the cardiac ventricles: they usually carry oxygen-rich blood away from the heart.

Arthroprosthesis This consists of two metal components that are anchored to the bone with a kind of "cement", and a central component made of "plastic" (polyethylene) that enables it to slide.

Athlete's heart This is a constellation of structural and functional changes that occur in the hearts of people who train daily for more than an hour. The changes are asymptomatic; signs include bradycardia, a systolic murmur, and extra heartbeat sounds. There are often abnormalities on an echocardiogram. Diagnosis is clinical and based on an echocardiogram. No treatment is required.

BDNF (Brain Derived Neurotrophic Factor) This is a polypeptide present in the brains of mammals, belonging to the family of neurotrophins. BDNF acts on certain neurons in the central nervous system and the peripheral nervous system, helping to support the survival of existing neurons and promoting the growth and differentiation of new neurons and synapses. In the brain, it is active in the hippocampus, cerebral cortex, and basal forebrain (or prosencephalon), vital areas for learning, memory, and thinking. BDNF itself plays an important role in long-term memory.

Bone The organic tissue that makes up our skeleton.

Bone remodeling This is the continuous process of structural adaptation of the bone to external stresses, to ensure that the bone's structure is always adapted to the real biomechanical needs of the specific individual.

Cartilage Connective tissue with a hard, elastic consistency that covers the joint surfaces of the bones and constitutes the scaffolding of organs such as the larynx and trachea; it also forms the embryonic skeleton of vertebrates.

Collagen A fibrous protein that constitutes the main component of the extracellular matrix and connective tissues, especially fibrous tissues such as cartilage and bones. It is the most common protein in mammals. There are different types of collagen depending on the various functions.

CSA (cross-sectional area) This is the cross-sectional area of a muscle and can be measured both in vivo and on images. It is used to see if a muscle has atrophied or not after any type of treatment, such as exercise.

Detraining Detraining or deconditioning is a phenomenon that indicates the partial or complete loss of physiological, anatomical, and performance-related adaptations associated with exercise as a result of a period of time, of variable duration, in which a reduction or cessation of physical activity occurs.

Disuse atrophy Decreased muscle mass due to lack of physical activity.

Elastic cartilage This is avascular and surrounded by perichondrium. Elastic cartilage gives greater elasticity to the organs it is found in (the epiglottis, auricle, and auditory or Eustachian tube).

Endorphin The generic name for organic polypeptide chemical compounds secreted by the pituitary gland, which have an effect similar to that of morphine. They play an important role as analgesics and in the processes of learning and memorization.

Fibrous cartilage This takes the form of small plates with indistinct boundaries, consisting of chondrocytes, a small amount of ground substance, and abundant fibrous elements (type I collagen). It is generally avascular and has no perichondrium. It is present in some articular cartilages, intervertebral discs, and menisci in the knee, mandible, sternoclavicular joint, and pubic symphysis.

Heart rate The number of heart beats per minute (bpm), which is the number of times the heart contracts to pump blood. It should not be confused with the pressure that is exerted by the blood inside the blood vessels. Along with the latter, as well as the respiratory rate and body temperature, heart rate is a vital function for the body.

Hippocampus This is part of the brain, located in the inner region of the temporal lobe. It plays an important role in the formation of explicit memories (declarative and semantic memories), in converting short-term memories into long-term memories, and in spatial navigation.

Homeostasis In biology, homeostasis is the ability of living organisms to retain their characteristics through self-regulation mechanisms as the external conditions of the environment change.

Hyaline cartilage This is the most common type of cartilage in mammals. In addition to a supportive function, hyaline cartilage is also responsible for giving the skeleton a certain degree of flexibility. The articular cartilage, located in the joints at the ends of the long bones, is devoid of perichondrium, forms a layer, and is very smooth on the surface, so as to facilitate the sliding of the joint surfaces.

Joint In the human body, joints are structures that connect two or more bone surfaces. They are composed of various different tissues: cartilage, fibrous tissue, ligaments, capsules, and membranes.

Ligament A ligament is a formation of dense, fibrous connective tissue with the function of holding two or more anatomical structures together (for example, two bone segments) or keeping an organ in the right position, i.e., helping to delimit openings or cavities where there are other anatomical structures (blood or lymphatic vessels, nerve trunks, etc.).

Locomotor system This is the result of the union between the skeletal system and the muscular system. The main anatomical elements that constitute it are: bones, cartilage tissue, muscles, joints, tendons, and ligaments. It enables humans to move and protects the internal organs.

Muscle tissue This is one of the four basic types of tissue that make up the bodies of animals. It is responsible for voluntary and involuntary movements of the body and is composed of: striated or skeletal muscle tissue (voluntary type); smooth muscle tissue (involuntary type); and cardiac muscle tissue (self-contracting type).

Musculoskeletal system *see* **Locomotor system**

Neurotransmitter A neurotransmitter (or neuromediator) is a substance that conveys information between neurons via synaptic transmission. Within the neuron, neurotransmitters are contained in vesicles, called synaptic vesicles, which are accumulated at the distal ends of the axon at points where it forms synapses with other neurons. The interaction between the neurotransmitter and the receptor / ion channel causes an excitatory or inhibitory response in the post-synaptic neuron.

Neurotrophin Neurotrophins are a family of proteins that determine the survival, development, and function of neurons.

Osteoarthritis/arthrosis A degenerative, chronic, and progressive disease of the joints. People suffering from osteoarthritis usually have pain with associated limited movement.

Osteoblast This is a cell that produces the organic matrix of the bone tissue itself, which consists of type I collagen fibers, proteoglycans, and glycoproteins; the premature, uncrystallized bone matrix produced by osteoblasts is called osteoid tissue.

Osteoclast This is a very large cell that is polynucleated and rich in lysosomes. It belongs to the monocyte-macrophage line, meaning that it derives from the hematopoietic mesenchymal cell. It has many eversions and wrinkles in its plasma membrane. Osteoclasts come into contact with the bone matrix and their function is to reabsorb the bone by eroding it through exocytosis enzymes and acid pH; they thereby contribute to calcium homeostasis and bone remodeling.

Osteocyte This is the most abundant cell type in adult bone tissue. Osteocytes are osteoblasts that have fulfilled their function of forming bone and remain trapped in the lacunae, small cavities inside the lamellae (layers in which the components of bone are organized).

Osteoporosis This is a systemic disease characterized by a reduction in bone mass and an alteration in the microarchitecture of skeletal tissue, which becomes more fragile and more vulnerable to the risk of spontaneous fractures or minor trauma.

Peak bone mass This is the amount of bone mineral tissue present at the end of growth, which is reached at around age 16-18 by females and around age 20-22 by males. From this moment on, the density and size of the bones no longer increase and remain constant throughout adulthood.

Physical activity Any effort exerted by the musculoskeletal system that results in a higher energy expenditure than in resting conditions.

Physical exercise This is a planned and intentional attempt specifically aimed at improving physical fitness and health. It can include activities such as brisk walking, cycling, and aerobic gymnastics, as well as active hobbies such as gardening and competitive sports.

Pulmonary circulation This is the circuit of blood vessels that starts from the right ventricle of the heart, branches into capillaries at the level of the pulmonary alveoli, and returns to the heart in the left atrium through the pulmonary veins, which transport the newly oxygenated blood.

Systemic circulation Systemic circulation is that part of the circulatory system that is responsible for sending blood (already oxygenated via the pulmonary circulation and rich in nutrients collected from the intestinal walls) to all tissues.

Tendons Tendons are all those sets of fibers that enable the muscles to transmit their contraction to a bone or joint, enabling the contractile tissue to perform its main function: movement. Tendon rupture results in a loss of the movement generated by the affected muscle.

Tenocyte The cell type found in the tendons. It ensures homeostasis of the tendon tissue, producing the extracellular matrix.

Veins Veins are blood vessels that start from the heart's atria and transport blood towards the heart. Most veins carry deoxygenated blood from the tissues.

Movement and the energy we continually convert enable us to live. But today, in an increasingly technological society that globally connects us through a tablet or mobile phone, we are at risk of moving less and less. Yet a lack of movement is the fourth leading risk factor for mortality!

In this booklet, the author explains what happens to our body if we do not move and how important physical activity is for our psychological and emotional well-being as well.

Francesco Oliva, Department of Diseases of the Musculoskeletal System, Faculty of Medicine and Surgery, University of Salerno.

Inside the comic:

The Astronauts' Disease

Texts by the students of class 3B of the Lugano 1 Middle School, Ticino, Switzerland.

Illustrations by Mirko Milone for the Scuola Romana dei Fumetti.

Repubblica e Cantone Ticino
Dipartimento dell'educazione, della cultura e dello sport