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QUO VADO BIOMECHANICS

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Abstract: *To understand history, we need to look through a wide-angle lens. The knowledge of history is an irreplaceable component to an awareness of the circumstances in which we find ourselves. Evolution, the gradual process lasting over millions of years, which generated the first hominids from the earlier primates. They differed from other kinds of living organism by bipedal walk. Except for this they showed ingenuity, diligence, and organizational skills, that provide other distinctions from further living creatures. The earliest hominids lived in the world about 20 000 years ago in several complex societies in Africa and Mesopotamia where laid the foundations for civilization, acquired the knowledge of agriculture, art, production of weapons, social structure, and politics. Archaeologists say it is the earliest example of modern culture, based on an extraterrestrial collection of the oldest toolkits that match those used by living humans. The development of their knowledge and skills continued, and with it the necessary tools. Just like today's generation, there was a need to preserve health, so the first, thus oldest implants were tooth replacements. Nowadays, dental implants are very sophisticated, just like many other tools and devices that were created according to the needs of doctors.*

Keywords: Hominid, evolution, biomechanics, gait, implants.

1. Introduction

The oldest evidence of walking on two legs comes from fossils of the earliest humans known, which date back to around 6 million years ago. The most widely accepted theory suggests that the australopithecines, who lived around four million years ago, were the first hominids to walk bipedally. The Laetoli footprints, which date back to 3.5 million years ago, provide solid evidence for bipedalism. The earliest indisputable evidence that our distant ancestors had shifted from four legs to two comes from footprints found in volcanic ash that date back to 3.66 million years ago. Evolution continues, and from hominids became presently humans - Homo sapiens Evolution brought a lot of new things, but as it turned out later, everything new is not perfect. Thanks to evolution, we are humans with bipedal walk, upright posture to see higher and further, and differed from other living creatures. Our anatomy changed to keep upright posture, thus muscular and bony elements had to change size, shape, and with these changes even the transfer of the forces (Niemitz, 2010).

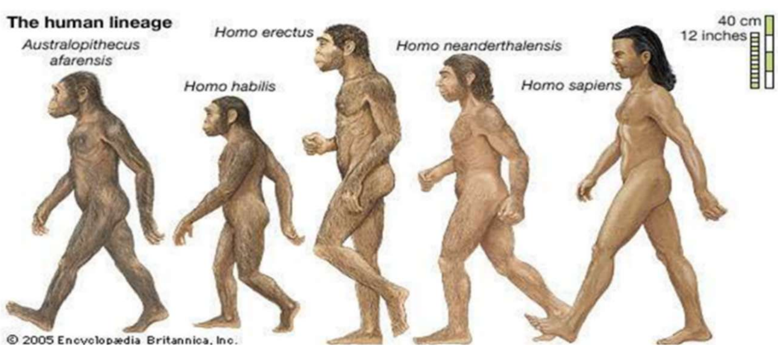

Fig. 1: Evolution of hominid to human in the lineage.

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What is the result of evolution? In 2020, low back pain (LBP) affected 619 million people globally and it is estimated that the number of cases will increase to 843 million cases by 2050, driven largely by population expansion and ageing, increasing of the weight, and decreasing of the muscle strength (WHO).

2. History of Science continues

Mayans, Egyptians, Mesopotamians, and Phoenicians were known for their developed knowledge in astrology and mathematics, but their understanding of nature events was combined with their myths. It was ancient Greeks, who left a record of human inquiry, concerning the relationship of nature and the world with respect to powers of perception at their era. The relative freedom of political and religious restrictions influenced the development of science between 6th to 4th century B.C. and made the first attempt to separate the myths from the knowledge together with building the foundation for scientific inquiry. The development of knowledge, together with awareness of the nature around and science, was classified by historians into seven historical epochs:

Antiquity (650 BC–200 AD),
Middle Ages (200 BC–1450),
Italian Renaissance (1450–1600),
Scientific Revolution (1600–1730),
Enlightenment (1730–1800),
Gait Century (1800–1900) and
20th Century (1900–2000),

where each was influenced by the prevailing reigning group. At each era you could find few famous personalities who enriched the world by art, science novelty, philosophy, and knowledge which, at the later stage of 20th century, become a foundation stone to a new branch of the science, later named Biomechanics.

2.1. Ancient Greeks

Greece flourished in the time of the Ancient Greeks era; scientists and philosophers taught and broadened the horizons of the younger generation. Socrates, the best philosopher at time, was known for spreading his philosophic idea that became famous; “first understand our own nature, to be able to understand the world around us”. Junior to Socrates, Plato began the philosophical inquiries leading to a concept of Western philosophy, psychology, and logic, as well as politics. His conceptualization of mathematics as the life force of science created the necessary womb for the birth and growth of mechanics. Aristotle, son of a physician, studied at Plato’s academy, was gifted for observation, great curiosity in anatomy, and the structure of living organisms. His first book presented observation of the movement of animals. Later he promoted qualitative, common-sense science, without mathematics, leading to deductive methods of modern science, and the fundamental scientific tools – deductive, and mathematical reasoning, which we inherited from the Greek era. These were the first steps towards the new science, that was later named “Biomechanics”.

2.2. Middle Ages

They are known as a “Dark age” that lasted over 1 000 years. This period starts at 476 yr. with the fall of the Western Roman Empire, and the rise of Islam at 610 yr. The creation of the new Holy Roman Empire in northern Europe at 800 years was followed by Medieval thinking. With the fall of Rome, much scientific knowledge was lost. The scientific inheritance from antiquity was saved thanks to translation of the work from Greek to Arabic. Until the rise of the Roman Empire, scientific development in general was discouraged. During the High Middle Ages (1000–1300) period, the population of Europe increased, and academic learning increased together with scholasticism, which developed into a philosophy of learning. Meanwhile, the Crusades and invasions between Christians and the Muslim continued. This period also saw significant growth of feudalism, and hierarchical system of rule. The Late Middle Ages were up-to the yr. 1492 at crisis. Warfare between the kingdoms, the Black Plague that killed a large part of the population, and at the same time, arts and culture progressed and gradually transitioned into a golden age of the Renaissance. At the Late Middle era, **Galen**, the anatomist, and physician left his monumental work, “On the Function of the Parts”, as the world’s standard medical text. His understanding of anatomy and medicine was affected by the then-current theory of humourism. What is the theory of humourism? The Four Humourism were bodily fluids (blood, yellow bile, black bile, and phlegm), that determined a person’s temperament and his imbalance that led to certain sicknesses dependent upon the type of humors, and its excess or deficit. The humors were connected to celestial bodies, seasons, body parts, and stages of life. Galen's anatomical reports, based on dissection of monkeys and pigs, remained uncontested until 1543, when printed descriptions and illustrations of human dissections were published in the work *De humani corporis fabrica* by **Andreas Vesalius** where Galen's physiological theory was accommodated to new observations. Galen's theory of the physiology of the circulatory system endured until 1628, when **William Harvey** established that the blood circulates with the heart acting as a pump.

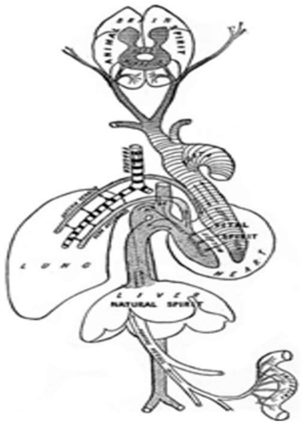

Fig. 2: An interpretation of Galen's human "physiological system".

2.3. Italian Renaissance

After the "Dark age", a new way of life was brought, that was characterized by freedom of thought, which revitalized scientific work, laid the foundations of modern anatomy and physiology, and introduced the first studies of human movement, with relation to muscle activity. The foundation of modern anatomy was based on autopsy observation, and dissection. **Leonardo da Vinci**, self-educated artist, observed the body of humans and horses during their movement, to understand the mechanics of their motion, and provide the mechanical analysis of human movement in relation to bones, muscles, joints, etc. He also contributed to engineering, mainly to mechanics, and several military and civil engineering projects. Already mentioned **Andreas Vesalius,** taught his anatomical theories, and acknowledged that human anatomy could only be learned from dissection and observation. He stimulated scientific debate about the relationship between the muscles and nerves. Leonardo Da Vinci, Andreas Vesalius, Bartolomeo Eustachio, and Costanzo Varolio furthered the study of neuroanatomy. **Nicolaus Copernicus** was Renaissance polymath, his most important contributions was in the field of astronomy, and the concept of a heliocentric solar system in 1514. The Revolutions of the Heavenly Spheres not only revolutionized astronomy, but revolutionized science by reintroducing mathematical reasoning, the antithesis of Aristotelian common-sense physics. It had direct implications for biomechanics, and the desire to explain the orbits of the heavenly spheres led directly to the development of mechanics.

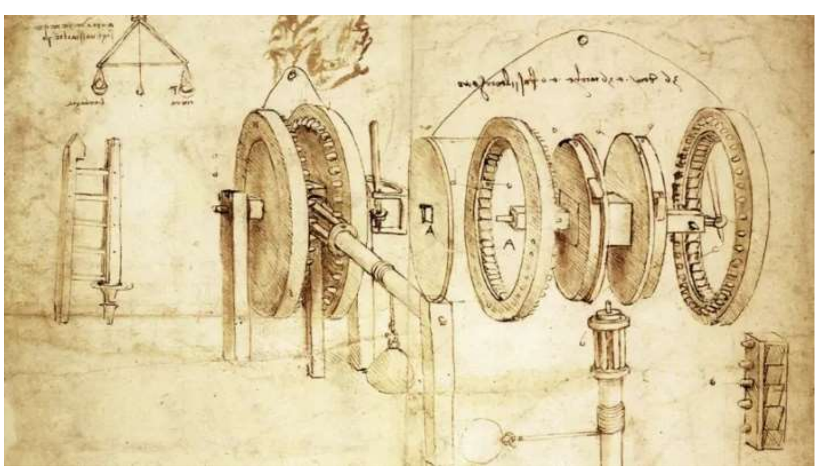

Fig. 3: Vintage Leonardo Da Vinci art work.

2.4. Scientific Revolution

17th century and beginning of the 18th century is associated with great names as **Galileo Galilei**, **Johannes Kepler**, **Rene Descartes**, and **Isaac Newton**. Intellectual freedom was highly respected, new scientific societies were emerging, and the exchange of new ideas was encouraged. Experimentation was the core of the new scientific methods. **Galileo Galileo's** work related to biomechanics of the human jump, and analysis of the gait of horses preceded the work by **Borelli**. **Santorio Santorio**, a physiologist, physician, and professor, that introduced the quantitative approach into life sciences, is therefore deemed the father of modern quantitative experimentation in medicine. **William Harvey** became the first "cardiac biomechanic", and his concept of blood circulation is considered to be a scientific classic. He applied mechanical theory of the heart, and its function as a pump. He identified the mechanical nature of the vascular system. **Rene Descartes** was philosopher who devised Cartesian coordinate system that facilitate the possibility of describing the movement in the space. **Giovanni Borelli** was physiologist, physicist, and mathematician. He was born in Naples in 1608, and his De Motu Animalium, was published in 1680. At this work he extended the rigorous analytical methods, developed by Galileo in the field of mechanics, to the biology. Borelli was credited with earliest descriptions of the distinct phases of the gait cycle and the muscle action during walking. (Al-Zahrani, 2008) He contributed to the modern principle of scientific investigation by continuing Galileo's practice of testing hypotheses opposed to observation. He is called the father of biomechanics. The new instruments such as the mechanical calculator, compound microscopes, barometer, revolutionized physiology, and the focus on movement and motion persisted from 17th to 18th century.

Fig. 4: Compound microscope by R. Hooke (1671-1700).

2.5. Enlightenment

After the scientific revolution, the new phase had a significant contribution to a development of natural science, and the association with three mathematicians. **L. Euler** was a Swiss mathematician, physicist, astronomer, geographer, logician, and engineer who founded the studies of graph theory and topology. He is also known for his work in mechanics, fluid dynamics, optics, astronomy, music theory, and developed mathematical theories describing the motion of vibrating bodies and buckling beams. **D'Alembert** stated "Newton's third law of motion holds not only for fixed bodies but also for those free to move" that directly applies to the principles of kinetics of motion. **J. L. Lagrange** focused his work on analytical mechanics that expressed second Newton's law in terms of kinetic and potential energy. The 18th century provided new approach to physiology that was based on the philosophy "forms follow function" advocated by **M. F. Bichat**. The discovery of electricity amplified the interest in muscle research and understanding of the nature of muscles. **Baglivi** differentiated between the structures and functions of smooth and striated muscle. **D. Bernoulli** developed a mechanical theory of muscular contraction, studied mechanics of breathing, and the mechanical work of the heart. Every field of science needed tools for experiments or observation. Not everyone had possibility to use the microscope; that invention was dated to late 16th century, created by a modest Dutch eyeglass maker **Z. Janssen**. Janssen's microscope (Chodos, 2004) was nonetheless a seminal advance in scientific instrumentation. By the end of 18th century, the tools such as thermometer, refrigeration machine, weighing scale, compressor, lithography printing technique, and other sophisticated tools, modified for more holistic approach, thus more useful for studying human movements, and better understand the human body. **J. J. Rousseau** revived the idea of a complementary development of body and intellect. The invention of the steam engine by **J. Watt** started the industrial revolution, and the storming of the Bastille signaled the end of monopoly on sport and leisure by the upper class (Scaruffi, 2005).

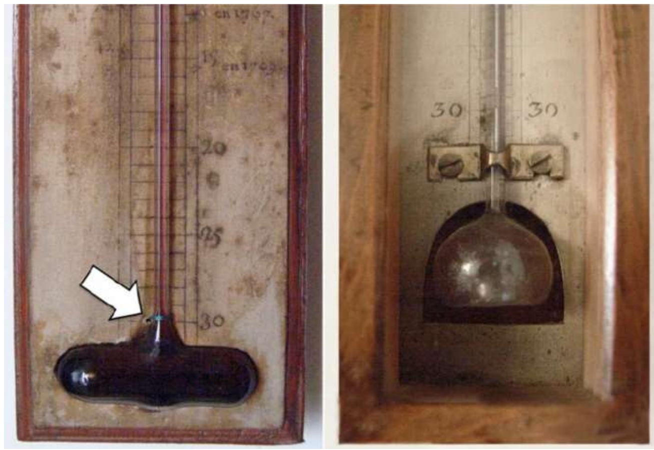

Fig. 5: Reaumur thermometer early version (left), improved version (right).

2.6. Gait Century

19th century continued with analysis of human gait. Science flourished with large number of educated scholars, interested to enrich the science by using they knowledge, and follow the research of human motion. The interest was supported by new equipment and tools that offer a new possibility to investigate the gait better than it was at 18th century, when their observation of the limb's motion could not be quantify due to lack of measuring tools, which resulted in many questions but very little answers. As a writer, **Honoré de Balzac** was interested in the analysis of gait. He also wrote a treatise called "Théorie de la demarche", in which he used his keen powers of observation to define the gait using a literary style. He observed that the gait is divided into phases and listed the factors that influence gait, such as personality, mood, height, weight, profession, and social class, and also provided a description of the correct way of walking. (Collado-Vázquez, 2015) At this time, scientists were oriented towards lower and upper limbs, and any visible and measurable parts. The first foundation stone, created from 17th to 19th century was laid for future science of the human motion. Except of the human motion, there was a desire to learn more about the movement, and how the motion is generated, and controlled by the muscles, and how the muscles work. The 19th century was full of inventions, and new theories. **L. Pasteur** stipulated that bacteria cause infection and disease, and the molecules of living organisms are asymmetric. English doctor **J. Lister** pioneers

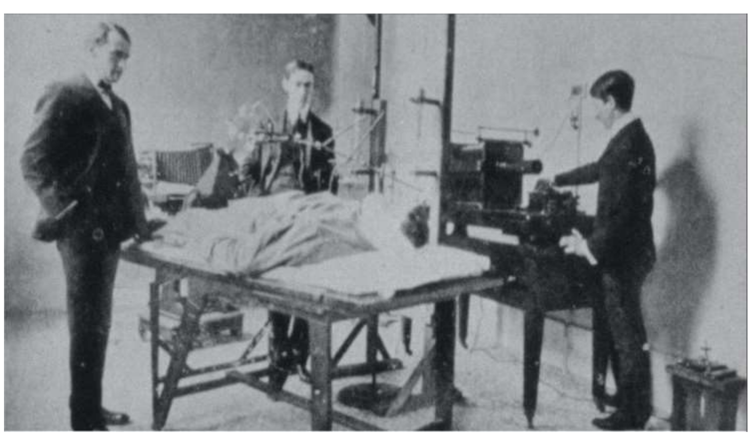

Fig. 6: Wilhelm Roentgen discovers the X-Ray.

the sterile surgery, that become common practice after 1890. The first fitted splints to treat orthopaedic injuries were made by the **DePuy** Manufacturing Company in 1895, as the world's first orthopaedics company. At the same time, it was **W. Roentgen** who discovered X-rays, that are invisible to the human eyes, and the X-ray machine was built within few weeks. **D. Mendeleyev** published his periodic table of elements, **T. Edison** invents the phonograph, **E.-J. Marey's** design a chronophotograph, **S. R. Cajal** proved that the neuron is the elementary unit of nervous system, that processing tasks in the brain, **Lumiere** brothers invented cinema. Another important contribution based on very simple measurements was attained by brothers **Willhelm** and **Eduard Weber**, working in Leipzig. Their work on wave theory was published in 1825, and a treatise on the mechanics of walking in 1833. Both **J. E. Marey** in France, and **E. Muybridge** in America, made significant advances in measurement technology, by making rapid sequences of photographs of motion, and further developed **O. Fischer** in collaboration with **W. Braune**. **Jules Amar** developed a three-component force plate with a mechanical system compressing rubber bulbs and pneumatic transmission of the signals to evaluate the reaction force of the gait. His work is notable, as he was a rehabilitation specialist, driven by a clinical need (Baker, 2007).

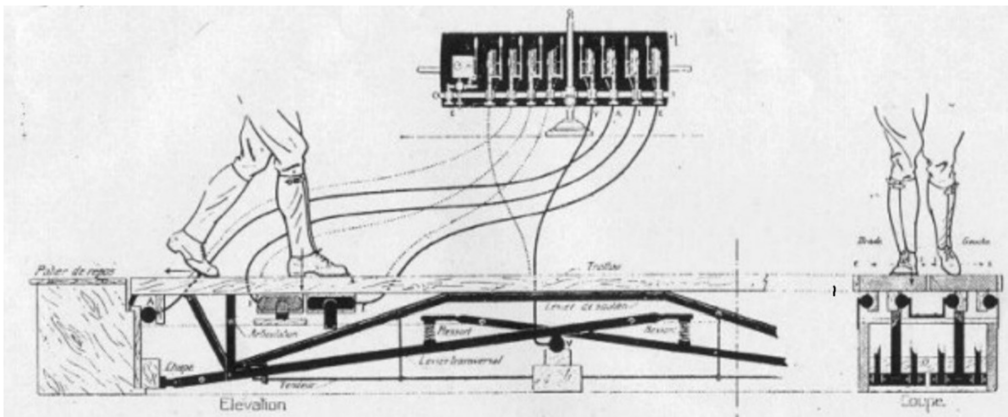

Fig. 7: Three-component force plate with a mechanical system and pneumatic transmission.

3. 20^{th} Century or Electronic Century?

At the turn of the 19^{th} to 20^{th} century, major developments were made. Due to war at the start of the new century, there was a need to heal broken bones, and amputation of the legs, for which the surgeons needed blood, that forced the scientists and engineers to try to solve these problems. **DePuy** Johnson & Johnson came up with their invention to produce metallic splints to heal broken bones.

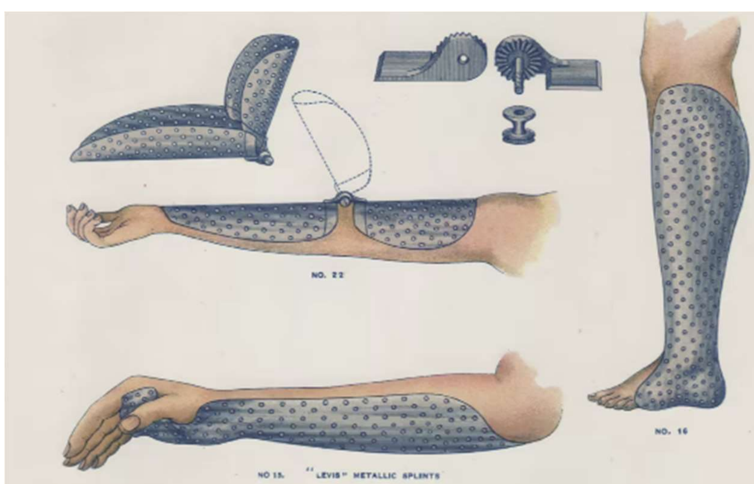

Fig. 8: Metallic splints to heal broken bones.

Australian scientist **Karl Landsteiner** discovered in 1901, four distinct blood types, due to unique antigen, present on the red blood cells' surface. In 1907, was done the first successful blood transfusion by doctor **R. Ottenberg**, but this invention was not suitable for situations when the blood is stored for some time outside of the body. A team headed by **Verne Inman** and **Howard Eberhart** made major advances in America shortly after the Second War, by developing force plates and understanding of kinetics. **David Sutherland** and **Jacquelin Perry** pioneered clinical applications in America, and **Jurg Baumann** in Europe. At time of the war, there was a need to keep good sterility for surgery, that was provided by use of the seamless glows for surgery and invented an “irrigation system” **Carrel-Dakin**. The deadly epidemic at 1919 call for solution, thus face masks were created. The first electron microscope, that was invented by German physicist **E. Ruska** and engineer **M. Knoll** in 1931, opened a new “science area”, and at 1938 was sold first updated type of microscope, named "transmission electron microscope."(Shampo, 1997).

Fig. 9: The first electron microscope.

DNA’s structure was discovered in 1953 by **J. Watson** and **F. Crick**, which suggested a method of replicating genetic material. At year 1958 was founded a research study group in Switzerland **AO** (Arbeitsgemeinschaft fur Osteosynthesefragen), which aimed to further advance in the science of treating bone injuries, and later expanded their research to treatments for joint reconstruction, spinal orthopedic trauma, and craniomaxillofacial injuries. Further development was supported by new activities, and introductions by new graduate programs in medicine, biomechanics, and bioengineering at universities across the whole world. Human ingenuity, diligence, organizational skills, and new growing industrial technologies manifested themselves in many areas. Area that was previously unbeatable and become surmountable, are healthcare and medicine. Scientists working in the field of the medicine and physiotherapy, organized in 1971 a seminar at America, followed by the conference, at which they established a society for scientists and students from America, naming it “*International Society of Biomechanics”* (ISB), that was established in 1973. The European seminar (1974) followed the same path, and set “European Society of Biomechanics” (ESB) in 1976 at Brussels. The name “Biomechanics”, was accepted after the long years of questioning, if the word *mechanics*, that in Greek language means “motion”, is suitable. Thus, the name became the official one for a new science, which is conform to the research of human and animals’ motion, their limbs, cells behaviour, and human fluids, including the blood. **Hay**’s definition of Biomechanics from 1973 is related more to an engineering mechanics, and the second-best definition from year 1974, formulated by **H. Hatze**, is a better version of the definition: *"Biomechanics is the study of the structure and function of biological systems by means of the methods of mechanics.”* (Hatze, 1974) The second half of the 20th century brought changes not only at the level of knowledge but as well in the growing interest of the young generation to learn more about the body and provides new opportunities for the jobs. Within a few years, biomechanics, that was considered to be a science of gait, started to diversify into branches of specialized biomechanics areas.

3.1. Motion Analysis

This branch of biomechanics continues to analyze motion, using modern systems. The first modern motion laboratory was established at University of California, Berkeley. The first motion laboratory in Europe was the University of Giessen in 1607 as a Lutheran university. ETH Zurich founded their laboratory on 7th February 1854 by the Swiss Confederation, that was modernized on the turn of the century. Modern motion laboratory system records positions of all markers, attached to the skin of a tested subject, then are processed by a digital system to obtain trajectories. Presently, the basic capture system is normally settled from

Fig. 10: Subject with markers and attached sEMG device.

a minimum of six fast infrared cameras, reflective markers, the computer with VICON system code, and usually three force plates. Recorded data are provided in two forms, one is .CSV data suitable for Excel, and the other are in form .c3d, which is a special form used by biomechanics software Mokka and AnyBody. Another tool that can be synchronized with the basic system is an electromyography system (EMG), that has two forms. The clinical system of EMG records the muscle activity invasively via needle, while the laboratory system records the muscle signal from the surface (sEMG) via electrodes. These EMG's record a potential (eV) value, which is recompute to the muscle force in Newton's units. Improved motion capture

Fig. 11: Simulation with AnyBody and VICON data.

technology has enabled more accurate tracking, hence better analysis of human or animal movements, and aids in understanding gait patterns, improving athletic performance, injury prevention, and rehabilitation strategies, which has grown into the wide range of uses that knowledge can achieve. Another step forward can be done with software AnyBody. The motion trajectory is recorded via VICON system, and muscular forces are computed using the inverse dynamics of muscle system applied on recorded data .c3d. The general skeleton of the human subject can be used for simulation of different activities, including the motion of a subject at work with a bicycle or any elements.

3.2. Medical Implants and Prosthetics

From the beginning of mankind, humans used dental implants to replace missing teeth. The first dental, stone implant, was prepared and placed at the mandible in the early Honduran culture around 800 AD (Ring, 1985). The teeth problem was, is and will still be, thus even the implants will exist but more sophisticated due to the latest technology, and materials, same as the second implant in history line.

Orthopaedics is a medical specialty that focuses on diagnosis, and treatment of problems related to the musculoskeletal system. Their orthopaedic implants were the second in a line of the implant's history. Though the date at which an orthopaedic implant was first used cannot be ascertained with any certainty, the fixation of bone fracture using an iron wire was reported for the first time in a French manuscript in 1775 (Hernigou, 2016). The first techniques of operative fracture treatment were developed at the end of 18th and start of 19th century. Presently the surgeon can provide replacement of the big joint such as a hip, knee, fix a fracture, and many other supports that belong to the group of orthotics. Orthoses treat certain conditions of the body such as scoliosis, ankle instability, etc. The first evidence of the use of spinal orthoses in the form of a traction device, can be traced to Galen in 1889 (Moore). The prosthesis is a man-made substitute for a missing body part. A 3 000-year-old mummy was recently discovered sporting a prosthetic big toe. The toe is one of the oldest examples, but from pirates' peg legs to Tycho Brahe's

Fig. 12: Prosthesis of upper arm.

metal nose, replacement body parts have a long and inventive history (MacDonald, 2017). Since each person is an individual one, it is very difficult to precisely adjust the artificial prosthesis for a specific patient. Unfortunately, there are few specialists who can process prosthesis or prosthetics. Till now, we are talking about problems that mainly concern visible or tangible segments of the body. The turn of the 20th to 21th century is marked by a new cardiac implants. The heart is the most significant and vital organ, without it we could not live. In 1628 William Harvey proved that the heart works as a pump but full knowledge of its function was found at a later stage. It is one of the complicated organs that cannot be controlled by anyone nor the brain, as it is controlled by the SA node, which generates the electrical stimulus. If the heart is diseased, and the fibres of electrical conduction are damaged, then the heart beating becomes arrhythmia, and might lead in the stop of the heart. The solution of the mentioned pathological behaviour of the heart calls for implantation of the pacemaker device, containing a pulse generator with built a microcontroller, endocardial leads which have the dual capability of sensing and pacing, and a battery. Since 1812 the inventors were looking for solution how to create a totally artificial heart.

It was in 1982, when the first permanent artificial heart was transplanted. The artificial valves were used from 1952 with a first valve created from the caged with the ball inside, in 1969 new version of tilting-disc valve, and 10 year later bi-leaflet valve. The pacemaker's battery life is limited to 7–10 years for modern pacemakers; thus, the patient must undergo an operation to change the battery. Inventors came with a number of ideas, and one of it is harvest the energy from mechanical energy that will prolongs the life of the battery. A similar task came from the cardiac surgeon; to monitor the behaviour of the valve and observe if the valve doesn't have any unwanted elements or moss.

Fig. 13: Orthopaedic implants.

3.3. Sports Biomechanics

Investigations into sports performance have expanded, involving detailed biomechanical analyses to optimize techniques, prevent injuries, and enhance athletic performance across various sports disciplines. Sport biomechanics is only one part of sport medicine, that works with other disciplines such physiology, psychology, and pathology phenomena. Active athletes have a 50 % chance to sustain an injury, from common are sprain, strain, fractures, dislocations, that must be treated medically. Each sport can have a different injury; thus the sports are split into three types: *collision* sports (rugby, American football, ice hockey), *contact* (basketball, baseball, soccer, water polo, etc.), and *non-contact* (archery, badminton,

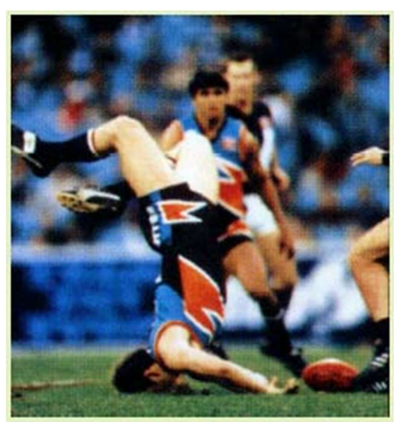

Fig. 14: Injuries in rugby.

bowling, fencing, skiing, etc.). It is important to reduce the risk of injury, so prevention starts at physical condition, good nutrition, and attention to the selection, and fitting of gear and equipment. The physical aspects, the psychological and emotional aspects play a game in the performance. It is a common practice that each sport club has its own team made of professionals in different therapeutic careers that work closely together. Biomechanics specialists provide quantifying tasks, such as an evaluation of the selected muscles, and providing the muscular forces to a physiotherapist, and discuss the strategy how to improve the performance. Even though ballet is not a sport, it is a similar position for the ballerina, with a small diversion in term of questions and solutions. Ballerina must perform movements that create a smooth trajectory, and result of the analysis is qualitative evaluation.

Fig. 15: Precision of the trajectory.

3.4. Biomechanics in Ergonomics

Using biomechanics in combination with physiology is a good start to avoid occupational disease. Since many workers must repeat an uncomfortable movement for 8 hours throughout the work week and many months, they risk suffering from pain. Continuation of this situation can lead to physical, biological, and chemical hazard. After long time of suffering with pain, they can reach cumulative trauma disorder, and variety of muscular conditions due to incorrect posture, overexertion, or muscle fatigue. These problems must be solved from many reasons; financial problem for the company because the worker is very often out of work, regulatory agencies, reduce of the salary, and other issues. It is necessary to adjust the environment for the workers according to their age, physical ability according to the type of work, and health status of worker.

4. The scientific legacy

To review the history of science, is opening a new desire to learn even more, and widen your horizon. Uncovering the date when the European Society of Biomechanics was founded seems to be just a few years ago. Considering the existence of some discovery from the time BC feels impossible, because it took so long to establish new science Biomechanics. Through history you learn more about different inventions, and it feels that their appetite to bring some new, to understand why things move. Present centuries seem to be packed with novelties, and our days look too be short. There is no time to stop and think about how to improve our planet, our country. At Greek age, Biomechanics was just motion of humans and living creatures. Therefore, mathematics was the priority science, and as time went on, the medics privileged biology, anatomy, and physiology. Presently, even the doctors study mathematics, physics, cooperate with engineers, and bringing new ideas how to improve their devices that can provide a service for doctors, as well for the patient, so doctor can monitor internal organ, which is impossible to monitor by the medics.

5. Conclusions

Two requests from cardiology, found my desk with very challenging work. Two different medics with two ideas that have a different purpose but fit into the cooperation, and solution for final task.

Life is one big book of philosophy, but we often don't have time to open it. Now we must open a book that will open a part of engineering philosophy. Closing this conclusion with a few quotes.

> "Science can amuse and fascinate us all, but it is engineering that changes the world."
>
> *Isaac Asimov, American writer, professor of biochemistry*

“The aim of medicine is to prevent disease and prolong life; the ideal of medicine is to eliminate the need of a physician”.

William J. Mayo, Founder of Mayo Clinic

“What we usually consider as impossible are simply engineering problems… there’s no law of physics preventing them.”

Michio Kaku, Theoretical Physicist

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