BRIEF REVIEW ON THE HISTORICAL EVOLUTION OF KINEMATICS AND ITS APPLICATION IN CLINICAL PRACTICE

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ABSTRACT

Walking is one of the basics of human movement.
Once learned, walking becomes an acquired skill, therefore we are able to move automatically without thinking.
Over centuries, advances in science and technology have led to the study of human walking mechanisms.
Brief review on the historical evolution of kinematics and its application in clinical practice

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A brief historical

Walking is one of the basics of human movement. The attainment of motor skills involves a trial-and-error process which needs a quite long time (about 12 months) to be acquired since it is considered the first real achievement in every individual's life[(1)].

Once learned, walking becomes an acquired skill, therefore we are able to move automatically without thinking. We realize the importance of walking when its functions are compromised by external events or pathologies.

Furthermore, gait and posture are a sort of visiting card in the society: being able to understand body language signs, help us to get a lot of information on our interlocutors, whoever they may be.

Over centuries, advances in science and technology have led to the study of human walking mechanisms (Figure1).

The French engineer Jules Amar was one of the leading figures behind this new approach. He began to study the correct gait biomechanics in wounded war veterans.

With the advent of increasingly advanced technologies, important steps forward have been done to improve the accuracy of measurement of the force plate. Such kind of platform was perfected by E-J Marey but was used to record only vertical movements. With the help of G. Demeny, Marey managed to develop a three-dimensional measurement system, allowing him to use the method designed by F.W. Taylor to study the movements performed during motor tasks.

The scientist Amar is also known for the invention of various medical devices, such as the adjustable physiological crutch. Amar noted that ordinary crutches led to many cases of paresis among users and, through physiological analysis, he attributed the problem to the fact that many per-

sons bear their weight on the shoulder-piece of the crutch. To prevent this from happening, he developed a special crutch which bore the weight of the body, imparting to it a sort of oscillation, which accelerated the movement of propulsion and lessened the axillary pressure.... The wounded soldier had to be led, by successive stages, to rely less and less on the double support of the armpits, and to employ the muscles of the limbs, without fatiguing them[1].

sional force platform. He set up a true "dynamic pedobarographic" to assess the pressure distribution (longitudinal arc) using a rubber mat or a glass plate. With his platform it was possible to measure the mechanical force, to record the cutting components in relation to the ground and the load, thanks to the movements of five levers turned by a high speed camera that simultaneously recorded the kinematics[1]. (Coco, I volti ...). This allowed Eftman to observe the role played by the muscular

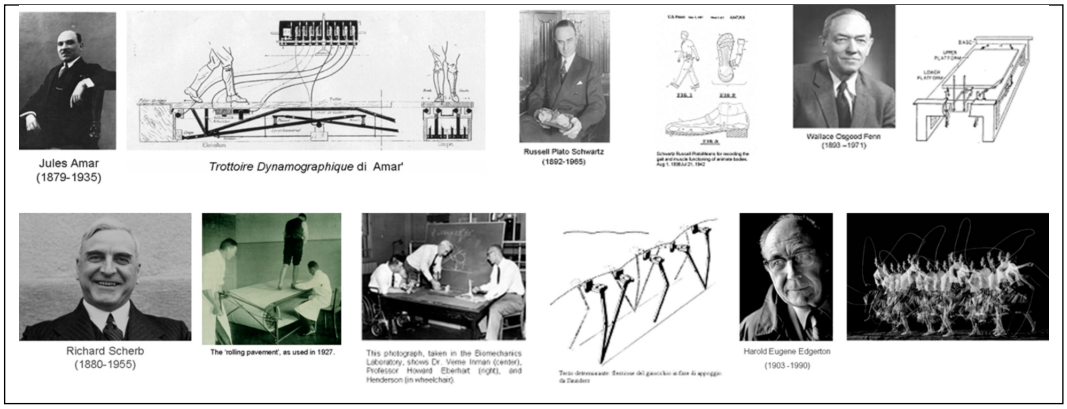

Figure1: Historical evolution of kinematics and its application in clinical practice.

Russell Plato Schwartz (1892-1965) was the Head of the orthopedic surgery at the University of Rochester, School of Medicine and Dentistry, from 1926 until 1957 (date of his retirement). Schwartz invented different measuring tools, among which he developed a specific instrument for gait analysis to be used for clinical applications. His main goal was to distinguish between normal and pathological gait.

Schwartz invented the pendulum basograph replaced in the early 1930s by a pneumographic (gait recorder based on Marey's principle). In June 1933, he developed an electrobasograph, an instrument used for the recording of (abnormalities of) gait, with the aim of checking true claims for damages made for injuries(1).

He also worked for prestigious American and European footwear companies dealing with foot design in order to check the best footwear[1].

In the United States the physiologist Wallace Osgood Fenn (1893-1971) studied the walking gait and, among a number of prestigious positions, he was awarded with the title of "leading physiologist" by The New York Times. We owe him the possibility to measure the horizontal component of mechanical forces[2].

Herbert Elftman from Columbia University developed an exclusively mechanical three-dimen-

system and its action on the skeletal system. He was able to calculate the speed and the angular movements of some muscles of the lower limbs[3,4].

Later, thanks to the studies carried out by D. Cunningham and G. Brown, the number of forces in the platform passed to a number of six.

The scientist Richard Scherb[5] (1880-1955) focused his studies on muscle physiology by assessing the muscles sensory feedback during gait. He was, in fact, able to study the involvement of phasic muscle activity during gait.

Scherb developed the first treadmill in the history using a ribbon created with an endless canvas, fitted around some drums that was moved manually on a wooden board. This invention was called rolling pavement and was used for diagnostic purposes.

The innovative idea consisted in using palpation techniques during gait on the rolling pavement in order to evaluate the muscle tone. He placed electrodes under the feet, under the heel, in the first and fifth metatarsal bones and connected them to pens which activated an electromagnetic field, thus allowing to record on a strip of paper the phases of foot contact while walking on the pavement which rolled at a constant speed.

Through the use of this tool it was possible to find out possible gait abnormalities. Scherb used this measurement system to plan recovery protocols after transplants.

The first electromyography recordings in the lower limbs were performed in 1944 by the group led by Aldo Arienti in Milan.

The Californian group made up of Saunders, Inman Eberhart, Sutherland, and Abate carried out studies on a sample of wounded soldiers of the Second World War. They developed a number of measuring techniques on motion in kinematics, kinetics and electromyography, by shooting a 10/2 film using different 16mm cameras positioned laterally on a frontal path.

Harold Eugene Edgerton, using stroboscopic photography techniques with multimedia exposures, published a number of works on kinematics and very stunning pictures.

It is important to note that what it is known about gait and walking is the result of a continuous and constant synergic work performed by different skillful and expert scientists. The mistakes made along their scientific path have been used as starting points to improve their studies.

The advent of modern technology and the development of sophisticated tools will increasingly contribute in the study on walking patterns and the implementation of ever more specific and tailored tests for gait analysis.

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