

Interview

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In this section, the JTAVR Editorial Team interviews an international protagonist in biomedical scientific research, to deepen unusual aspects among the current most discussed topics.



Movement analysis and postural biomechanics in forensic medicine

Interview with Marco Bernardini

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Biomechanics isn't a new research field. However, its clinical and practical use must follow an acceptable standard and uniform protocol. This requisite is even more so true in forensic medicine, when a medical legal decision has to be taken. Dr. Eng. Marco Bernardini was invited to the Senate of the Italian Republic to present his results, because recognized of significant national interest. JTAVR interviews Marco Bernardini with the aim of highlighting the importance of postural biomechanics to a wider and wider audience.

Interview by Fausto Passariello.

Question - What is the meaning of postural biomechanical assessment and why is it useful?

Reply - Postural biomechanical assessment means a mechanical analysis of posture and movement, through various instrumental tests with data processing, correlation and evaluation.

Instrumental diagnostics are often given little consideration, while subjective clinical, static and almost never dynamic evaluations prevail.

On the contrary, a postural biomechanical assessment is a fundamental integration to the specialist

visit in order to make the functional/postural aspects and the consequent adaptations objective and scientific. Furthermore, it is fundamental for a better therapeutic strategy and an accurate follow up.

The movement analysis and postural biomechanics laboratory, equipped with high-tech instruments, makes real functional deficits objective in accordance with precisely measured data.

Q - Is there a standard medico-legal protocol for the biomechanical analysis of posture, which could be disseminated internationally?

R - The method I propose has aroused much interest for five years among several medical examiners and lawyers in my city, but it has been deemed irrelevant for compensation purposes, because it is not officially recognized. The meeting with Prof. Pasquale Giuseppe Macrì, professor of forensic medicine, represented the turning point: we collaborated on some interesting and complicated clinical cases. Prof. Macrì was so impressed by the methodology used to support the forensic medical evaluation that he wanted to take care of its dissemination by publishing an entire chapter in a special issue of forensic medicine in the magazine: "Italian Journal of Prevention, Diagnostic and Therapeutic Medicine"¹. At the moment there is no single international forensic medical protocol and with this the article proposes a fixed point from which to start.

Q - And why talk about it now?

R - Because a communication channel was opened with the Italian Ministry of Health, thanks to which this special issue of the journal was recognized as being of significant national interest. For this reason, other Authors and I were called formally on June 20, 2024 to Palazzo Madama, seat of the Senate of the Republic, for the official presentation. The initiative was promoted by Senator Beatrice Lorenzin and during the event the role of scientific societies, health professionals and the importance of specialized journals, such as this one, in providing accurate and authoritative information in the health sector was addressed. The journal, with a high impact factor, highlighted technological, therapeutic and diagnostic innovations of particular relevance. In particular, my chapter¹ has been considered a novelty, at a national level, in the field of forensic medicine. It represents the recognition of a new diagnostic protocol useful for the attribution of medical responsibility and compensation for functional damage secondary to road and work accidents, an aspect that until now had not been adequately taken into consideration.

Q - Could you illustrate with examples how the support of biomechanics can be useful in the medico-legal field?

R - Biomechanical technology is of great importance in the forensic field, thanks to its ability to provide quantitative and repeatable analysis of human movement. Movement analysis systems are divided into three large macro areas:

1. **Dynamics:** Focuses on the relationship between the motion of a body and the forces that cause it. For example, using force platforms, it is possible to measure reactions to the ground, providing fundamental data for understanding the interaction between the body and the support surfaces;

2. **Kinematics:** Describes the motion of objects without investigating the causes that determine it. Using optoelectronic Motion Capture systems and inertial systems, the position and velocity of body segments can be measured precisely, both in linear and angular terms;

3. **Electromyography:** Analyzes muscle activations through the acquisition and processing of electrical signals generated by muscle contraction, allowing to evaluate the timing and intensity of muscle activation during movement.

A practical example is gait analysis (gait analysis), which evaluates kinematic parameters such as gait phases, step cadence and limb propulsion. This analysis can be integrated with surface electromyographic data to verify whether the muscles are pre-activated or post-activated with respect to the various phases of the step, thus determining the normality or abnormality of the motor pattern and the intensity of activation.

Other applications include assessment of cervical movements, upper limb abduction and flexion, ankle mobility, functional assessment of dental occlusion, etc.

Also important are:

- **Stabilometry**, which measures body balance by analyzing the oscillations of the center of pressure, revealing postural and functional imbalances, even secondary to surgical interventions or injuries;
- **Baropodometry**, a test which is also useful especially for understanding the pressure distributions of the feet during the static and dynamic phases of walking; the baropodometer should not be used to analyse postural oscillations because the most accurate instrument is the stabilometric platform.
- **Capture movement optoelectronics systems and force platforms.** The goal is to obtain quantitative, accurate and repeatable assessments, crucial for developing innovative and standardized functional deficit assessment protocols, shareable among all the actors in the medical-legal and rehabilitation process.

In conclusion, instrumental analyses in a biomechanics laboratory represent an indispensable aid in the forensic field, providing a scientific quantification of motor deficits due to structural and postural problems. The precision and accuracy of these techniques allow for the development of more effective therapeutic and diagnostic approaches, significantly improving the quality of assessments and treatments in the forensic and rehabilitation fields.

Q - Motion analysis and biomechanics are useful to compensate damages in the medical legal field. Why are clinical examination and diagnostic imaging not enough?

R - The focus of the medicolegal evaluation on a living subject concerns the study of the functional consequences of the injuries reported. The assessment of the impairments is generally based on medicolegal observations and documents certifying the patient's condition. However, this information often leaves room for partly subjective interpretations, making it difficult to accurately estimate the functional limitations of the subject. For example, a reduction in the mobility of a joint or the report of pain can only approximately indicate the functional impact of the injuries.

In this context, postural biomechanics offers a concrete and valuable application, especially in the study of impairments involving the locomotor system. Thanks to the biomechanical analysis of posture and movement, it is possible to identify and document in detail the impairment aspects, providing relevant evidence to support medico-legal evaluations.

A human movement analysis laboratory is therefore essential to obtain a fair assessment of compensation. Using advanced instruments, medical-legal assessments can be integrated with objective and quantifiable biometric and biomedical data. Biomechanical and postural tests offer a scientifically accurate picture of the damages suffered.

Furthermore, it is possible to reconstruct the dynamics of accidents at work or on the road using ad hoc models developed with high-level software, accurately determining the causal link. This digital modeling of the accident further supports the medical-legal assessment, facilitating the recognition of adequate compensation.

In summary, the integration of postural biomechanics in medico-legal assessments provides more precise and scientifically valid tools to determine the extent of damages, thus ensuring that insurance companies provide more appropriate compensation to injured people.

Q - Could the medical visit suggest a deeper biomechanical study, in analogy to the general collaboration between the ordering physician and the radiologist in diagnostic imaging?

R - Yes, the medical examiner's visit may indicate specific elements that need to be explored in greater detail, similar to what usually happens in diagnostic imaging.

To give a practical example: normally, the doctor can request a radiographic examination (RX) with a particular projection in order to clarify a diagnostic suspicion. During this process, the radiologist performs the prescribed examination, but has the faculty and competence to integrate other projections, if he deems it necessary, on the base of his professional judgment, experience and competence.

Similarly, the doctor or the coroner, formulating a diagnostic suspicion, can request a postural biomechanical analysis, aimed at studying specific motor activities. For example, the doctor requests the evaluation of the kinematics of walking and the expert operator can decide to integrate it with the evaluation of the motor pattern of some muscles of the lower limbs, by means of surface electromyography, studying also the antagonist muscles. As another example, the evaluation of the static plantar support is requested, to which the expert operator adds a dynamic evaluation to provide a more comprehensive picture.

Q - It seems that the article wants to redesign the role of the doctor and the expert in biomechanics (in particular the biomedical engineer) in the evaluation of postural functional damage. Can you add something about this?

R - A biomechanics laboratory must be equipped with many technologically advanced instruments, for which a long learning curve is required to use them in the most appropriate way possible. Furthermore, very often very complex tests are required, for which the protocols must be readapted to evaluate specific motor tasks. Various skills are therefore required such as the analysis of biomedical data and their interpretation, in-depth knowledge of statistics, mechanics and electronics as well as a solid knowledge of human anatomy and posturology. There are many healthcare and non-healthcare professional figures who can assist the doctor's work. Among these, the biomedical engineer, specialized in biomechanics and posturology, is of primary importance. He can act as the perfect glue between the technical-instrumental and clinical spheres and is able to manage a laboratory with mixed skills. This professional is able to collaborate effectively with clinicians, facilitating interdisciplinary communication and contributing to the improvement of medical-legal practices. It is a figure that is far from being in competition with healthcare professionals, as it plays a complementary role that makes functional damage scientific and objective, improving the doctor's diagnostic possibilities, aimed at obtaining appropriate compensation, in the interest of the patient.

Q - Does this new methodological approach have any implications from a forensic medical point of view in chronic venous insufficiency?

R - There are numerous indications that postural biomechanics may play a fundamental role in the diagnosis of chronic venous insufficiency, since it allows the identification of postural alterations and asymmetries in walking that are not clinically detectable. Asymmetries, often caused by injuries, could make unilateral chronic venous insufficiency evident², altering hemodynamics and causing venous stasis. However, on this topic the scientific

literature is poor and insufficient to justify medical-legal compensation.

Q - Can movement analysis and postural biomechanics have practical implications in diagnosis and therapy, as well as in the research of phlebopathies ?

R - Alterations in posture, foot, and more can act as important epigenetic factors, contributing to the clinical expression of a genetic primitive phlebopathy. These alterations influence the haemodynamics of walking, in other words the correct venous outflow during walking². When the motor pattern is no longer optimal, the systole and diastole phases, which regulate venous return, are also affected, worsening the vascular pathology.

The analysis of movement and posture, therefore, not only allows to identify these alterations in a precise and objective way but can direct towards a targeted therapy, performed by clinicians of different backgrounds, aimed at preventing the onset of varicose disease or aimed at reducing the onset of varicose recurrences. It is

important to note, however, that postural correction and movement care do not replace phlebological hemodynamic treatment but integrate it, improving therapeutic outcomes, especially if associated with conservative interventions. In conclusion, it is hoped that, in the near future, a more in-depth understanding of the causal relationships between postural alterations and alterations of the venous system can be achieved thanks to biomechanical analysis, thus contributing to the advancement of scientific literature on the subject.

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