BIOMECHANICS CORE

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ABSTRACT

Introduction: *The study of movement is possible through an interdisciplinary approach that embraces various scientific fields. knowledge of the functional morpho structure (length and shape, cellular composition, mechanical characteristics, etc.), in addition to the motor experience of the tested subject, allows an accurate study of a given movement or posture.*

Aim: *Aim of this study is, through the treatment of scientific texts and articles, to direct sports and rehabilitation operators towards a more holistic vision in order to improve their training and rehabilitation programs and, therefore, reduce injuries.*

Materials and methods: *The study was conducted through the treatment of scientific literature.*

Results: *Through the scientific literature, an overview was made of the general meaning of biomechanics and its applications. Then we focused on the anatomical structure of the core region illustrating its structural and functional characteristics. Finally, we directed the focus on a particular exercise, the sit up, highlighting its biomechanical characteristics.*

Conclusion: *the study confirmed the importance of biomechanical studies in order to provide professionals with indispensable tools to program and structure effective work protocols for the improvement of certain motor gestures and for the prevention and recovery of accidents.*

Keywords: *Core analysis, core training, core stability, human movement.*

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Introduction

Body movement is a fundamental factor in determining the relationship between the individual and the environment[3,4,5]. It is intended as the precise linking of multiarticular actions that follow a precise order (kinetic chain) based on muscle synergies which, to be expressed effectively, must be learned through the right methodologies in certain periods of the individual's life[12,28,29]. Human movement is the result of the concatenation of events, structural and coordinated, which are pre-established and readjusted through the processes of neuro-muscular maturation and motor learning[30].

The study of movement is possible through an interdisciplinary approach that embraces various scientific fields. The study of human movement has an interdisciplinary[8] character in which various types of knowledge make their contribution to try to understand the laws and peculiarities that govern it. The physical laws, typical of mechanical physics, allow you to understand what is generally called the executive aspect of movement. Biochemistry allows us to understand the mechanisms that provide energy to the muscles so that movements and postures can take place. Neurophysiology allows an understanding of the organizational, intentional and motivational aspect of movement. Psychology clarifies the deep motivations for movement, but also the motor difficulties, in particular, in the child and adolescent.

This work illustrates how scientific knowledge, such as anatomy and biomechanics, contribute significantly to the structuring of effective interventions by specific operators in order to improve certain postures or functionality and prevent or recover injuries. Through the treatment of scientific texts and articles, efforts have been made to clarify the functional structure of a district considered fundamental for

both statics and dynamics. The aim is to direct sports and rehabilitation operators towards a more holistic vision in order to improve their training and rehabilitation programs and, therefore, reduce injuries. Muscle injuries are the most common complaints in sports medicine practice, and noncontact muscle strain injuries are usually seen in sport events involving high-speed sprinting, jumping, kicking, and rapid changes of direction[18].

A specific exercise that is often used in strengthening programs in the core region will be considered, with the aim of clarifying how the osteoarticular and muscular structures interact with each other in the various anatomical and geometric angles considered.

Materials and methods

The methodology used for this treatment is that of the revision of the literature through the consultation of the most recent scientific journals and texts. The structure was highlighted not only of the individual components of this particular district, but above all the synergies that allow particular patterns.

Discussion

Biomechanics

Biomechanics is that multidisciplinary science that applies the acquisitions and laws of classical mechanics to the study of living organisms[15, 17, 22, 23, 25, 26].

Various authors have given a definition of biomechanics:

• Hatze defines Biomechanics as "…the study of the structure and function of biological systems through the methods of mechanics" [15];

•Biomechanics can be considered as that sector of sports sciences that applies the laws of mechanics to human performance.

The main object of study of biomechanics is the movement of the human body in all its expressions. In particular, it deals with:

• The distribution of bone stresses;

• Joint-level actions;

• Muscle intervention during movement and postural maintenance.

In summary, the biomechanics of the musculoskeletal system is the science that examines the forces that act on the musculoskeletal system (external forces, muscle forces and joint loads) and the effects produced by these forces (movements, deformations, etc.)[22]. The field of application of biomechanics can be clinical, related to functional assessment or rehabilitation, or in the sports field, with the aim of improving performance and reducing injuries. In addition to these areas, biomechanics has a field of application in other sectors such as clothing.

Core biomechanics

The word "core" derives from English and has sparked different debates and various discussions about what it designates: literally translated into Italian it means "center or core of an object". The importance of this musculature in the movements of the trunk and in maintaining the stability of the spine, as well as its role in the prevention and treatment of pathologies of the spine, has led many scientists to generate a large number of studies starting from the years' 50[16, 19, 20].

Over the years, we have gone from the descriptive investigation[10], where the effects of a specific training were assessed through specific methodologies and exercises, to the experimental investigation, where, through surface electromyography, the myoelectric signal of the specific muscle was evaluated during a specific exercise.

Today, the interest has shifted towards a more global vision of the human body in which movement training tends to replace the conditioning of the single muscle. So also, the concept of abdominal muscles has gradually turned into the Core Region, to justify a broader overview of an area dedicated to controlling stability and global body movements.

With reference to the human body, the core is represented by the coxo-lumbo-pelvic complex and constitutes the center of the kinetic chain from which all the movements that are transmitted to the upper and lower limbs depart[11, 21]. In the past, Joseph Hubertus Pilates had called this region a "powerhouse" (house of power), considering it a load-bearing element and primary source in the generation of all movements. His method is now widespread throughout the world. According to functional anatomy, the main purpose of the core region is the prevention of movement, that is, to provide adequate isometric support of the torso during the execution of a movement.

Bergmark, in his 1989 work "Stability of the lumbar spine. A study in mechanical engineering", to define the composition of the core (Figure 1), distinguishes two separate, but interconnected systems, defined by himself the local muscular system and the global muscular system[1].

The local muscular system, also called internal unit or joint support system (2, 7, 22), is made up of:

- Abdominal transverse
- Multifidus;
- Internal obliques;
- Diaphragm;
- Pelvic floor muscles.

The global muscular system, also called the external unit, includes:

- Rectus abdominal;
- External obliques;
- Column erector;
- Square of the loins.

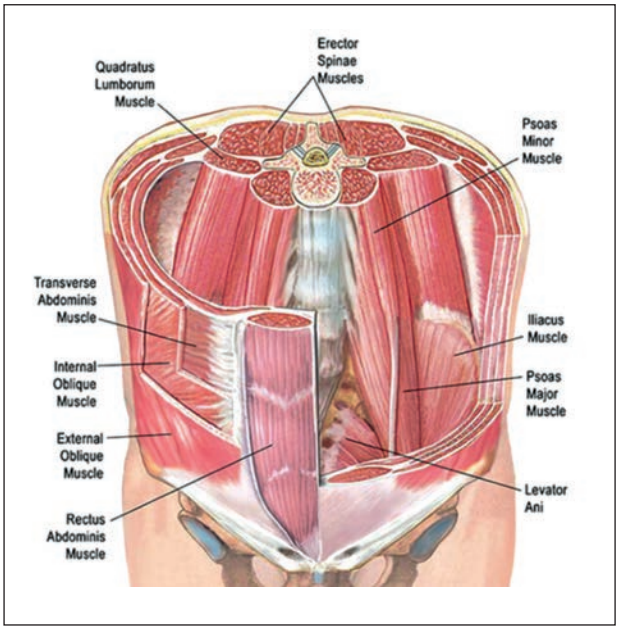


Figure 1: Core region (Paul B. Roache, 2012).

These muscles represent the vital link between upper body strength and lower body strength [7, 11, 13].

The centre of gravity (Figure 2) is contained within the core and all movements originate from it. A strong and efficient core is necessary to maintain a correct postural balance in the whole system of human movement[9, 21, 27].

The core acts as the anatomical basis of the movement of the distal segments, ensuring proximal stability to ensure distal mobility. Therefore, optimal length-tension ratios give efficiency to the neuromuscular system during movement management, allowing acceleration, deceleration and stabilization during movement.

This allows an improvement in terms of posture, efficiency in the movements of daily life or typical of sports actions, contributing fundamentally in the prevention of injuries.

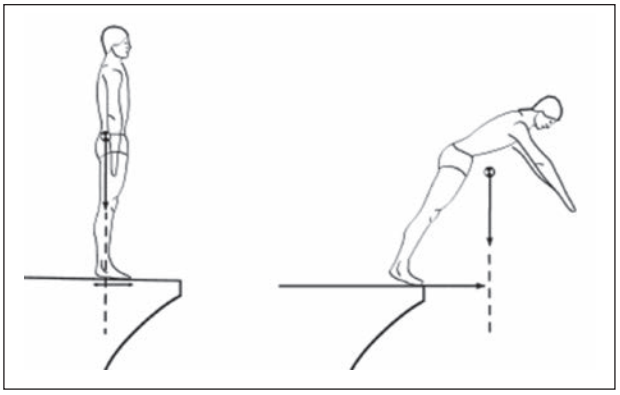


Figure 2: Centre of gravity (Knudson D., 2007).

Biomechanical studies allow us to study, through evaluation and observation, what are the forces that generate certain movements and therefore to optimize interventions in terms of training to improve the qualitative and quantitative aspects.

A definition of Carmelo Bosco is very significant "*...Training is an art that is based on science... and training without evaluation is an aimless itinerary...*"[6].

Practical exemples

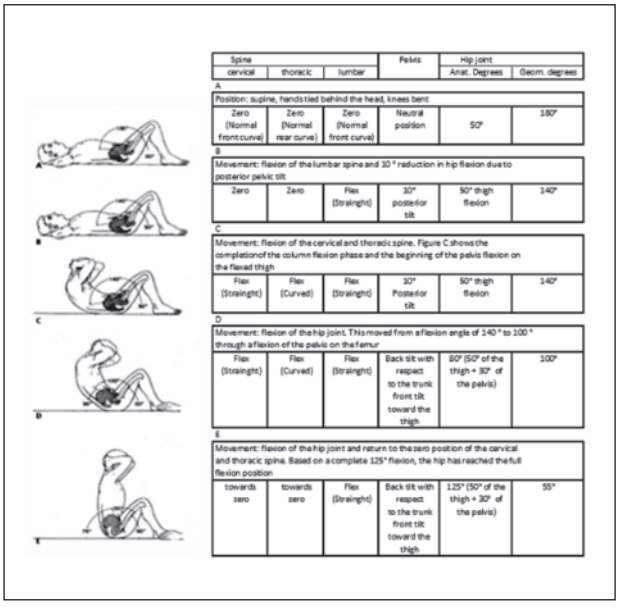
Taking the rectus abdominis muscle as an example, we can decipher its role (function) based on the insertions, the direction of the muscle fibers, the cross section, the length of the fibers, the lever arm generated during the movement, etc.

The rectus abdominis muscle is made up of two muscle bands extended along the front face of the abdomen, on one side and the other of the midline. They have the upper insertions on the fifth, sixth and seventh ribs and on the costal cartilages and also on the xiphoid apophysis. This muscle band is intersected by aponevrotic insertion bands. The width of the muscular body is significantly less than below the navel to give rise to a powerful tendon that is fixed on the upper margin of the pubis, on the pubic symphysis and with some offshoots towards the opposite side and towards the adductors[2, 7].

The rectus abdomen, supported by the other muscles of the abdominal wall, is a powerful flexor of the trunk[14, 13, 31]. It is a very energetic action as it is carried out through very long lever arms.

The insertion on the pubis of the rectum seems to act in shortening in the movements of mobilization of the pelvis on the trunk. Abdominal insertion on the trunk comes into play in the movements of mobilization of the trunk on the pelvis. Abdominal insertion on the trunk comes into play in the movements of mobilization of the trunk on the legs[14, 31].

In the figure (Figure 3)[20] below we take as an example a very frequent exercise for strengthening the core: the sit up, a complex exercise that involves the mobilization of an entire kinetic chain and, therefore, consequently the activation of a very large muscle chain. The whole first part concerns the flexion of the lumbar spine with the involvement above all of the abdominal rectum, in the second part, as soon as the lumbar spine has finished its flexion, the hip flexion begins to be borne by the ileus psoas and the rectum of the femur , a third part may be added in which the hip reaches its maximum flexion and the spine extends again by the extensor muscles of the column.



Spine			Pelvis	Hip joint	
cervical	thoracic	lumbar		Anat. Degrees	Geom. degrees
A					
Position: supine, hands tied behind the head, knees bent					
Zero (Normal front curve)	Zero (Normal rear curve)	Zero (Normal front curve)	Neutral position	50°	180°
B					
Movement: flexion of the lumbar spine and 10 ° reduction in hip flexion due to posterior pelvic tilt					
Zero	Zero	Flex (Straight)	10° posterior tilt	50° thigh flexion	140°
C					
Movement: flexion of the cervical and thoracic spine. Figure C shows the completion of the column flexion phase and the beginning of the pelvis flexion on the flexed thigh					
Flex (Straight)	Flex (Curved)	Flex (Straight)	10° Posterior tilt	50° thigh flexion	140°
D					
Movement: flexion of the hip joint. This moved from a flexion angle of 140 ° to 100 ° through a flexion of the pelvis on the femur					
Flex (Straight)	Flex (Curved)	Flex (Straight)	Back tilt with respect to the trunk front tilt toward the thigh	80° (50° of the thigh + 30° of the pelvis)	100°
E					
Movement: flexion of the hip joint and return to the zero position of the cervical and thoracic spine. Based on a complete 125° flexion, the hip has reached the full flexion position					
towards zero	towards zero	Flex (Straight)	Back tilt with respect to the trunk front tilt toward the thigh	125° (50° of the thigh + 30° of the pelvis)	55°

Figure 3: Biomechanics of sit up exercise (Kendall, 2014).

We can say, therefore, that whatever the type of work used, it is not the abdominals that produce the elevation movement of the legs on the trunk (Figure 4) as they do not have insertions on the femur.

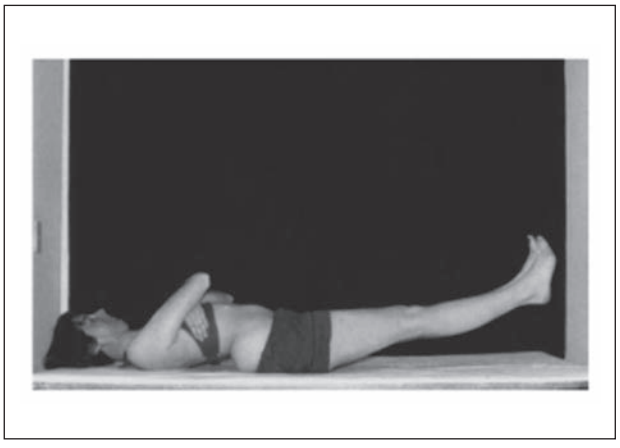


Figure 4: Fflexion of the femur on the trunk (Kendall, 2014).

The contraction of the abdomen during this type of movement is given by a stabilization mechanism. The elevation movement of the legs is obtained mainly through the ileus-psoas and the rectus femoris with a very disadvantageous lever arm. a traction is exerted simultaneously on the three insertions: on the femur, on the pelvis and on the lumbar spine.

Given the insertions of the great psoas (which originates the body of the twelfth thoracic vertebra, the bodies of the first four lumbar vertebrae and the intervertebral discs interposed and fits on the small trochanter of the femur) and the iliac (which originates in the iliac fossa and inserts on the small trochanter of the femur), which together form the ileus-psoas, their contraction generates a double mechanism: drag of the pelvis in anteversion and increase in lumbar lordosis.

Then the abdominal contraction intervenes which has the purpose of preventing or limiting the anteversion of the pelvis.

Conclusion

The main purpose of this intervention is to highlight the importance of an in-depth knowledge of the sciences of movement, especially biomechanics, of anatomy and human physiology in order to start an effective work aimed at improving posture and movement. In the past this was possible through descriptive investigations and evaluation of specific training methodologies, today, with the use of specific adequate instruments (e.g. surface electromyography, dedicated software, protractors, etc.) it is possible to define in a much more precise way which are the forces that generate a certain movement.

Biomechanical studies provide professionals with indispensable tools for programming and structuring effective work protocols for the improvement of certain motor gestures and for the prevention and recovery of accidents.

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