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Posture and posturology, anatomical and physiological profiles: overview and current state of art

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Summary. *Background and aim of work:* posture is the position of the body in the space, and is controlled by a set of anatomical structures. The maintenance and the control of posture are a set of interactions between muscle-skeletal, visual, vestibular, and skin system. Lately there are numerous studies that correlate the muscle-skeletal and the maintenance of posture. In particular, the correction of defects and obstruction of temporomandibular disorders, seem to have an impact on posture. The aim of this work is to collect information in literature on posture and the influence of the stomatognathic system on postural system. *Methods:* Comparison of the literature on posture and posturology by consulting books and scientific sites. *Results:* the results obtained from the comparison of the literature show a discrepancy between the thesis. Some studies support the correlation between stomatognathic system and posture, while others deny such a correlation. *Conclusions:* further studies are necessary to be able to confirm one or the other argument. (www.actabiomedica.it)

Key words: muscle-skeletal system, vestibular receptors, posturology, posture, spinometria

Introduction

The aim of this work is to provide an overview of the postural system and the discipline that studies posture, known as posturology. It is known that the posture is a set of interactions between muscle-skeletal system with afferent and efferent pathways of the central nervous system and whose main role is to keep your body in a state of muscle-skeletal balance, protecting the supporting structures of the body against injury or progressive deformity.

In humans three physiological curves balance the spine: the cervical and lumbar lordosis convex forward, and the dorsal kyphosis concave forward. These curves are formed and stabilized around 5-6 years, after proprioceptive maturation of the foot. The three curves maintain the balance and they provide support and resistance against longitudinal pressures (1-4).

The most important curve is the lumbar lordosis, posteriorly concave, formed by 5 vertebrae starting from the sacrum. The thoracic curve is formed by 12 vertebrae and it forms an anterior concavity called kyphosis. The 7 vertebrae of the cervical spine forms the cervical lordosis in rear concavity (5,6).

The complete development of postural function takes place at around 11 years old, and then remains stable until about 65 years old (7).

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Posture

The term "posture" means the position of the body in space. It indicates the position of the body in space and has the purpose of maintaining the body in balance, during the dynamic movements and the stasis. Several factors contribute to the posture, including neurophysiological, biomechanical and psychoemotive factors, linked to the evolution of the species (8,9).

Posture is an automatic and unconscious position (9,10) and it represents the body's reaction to the force of gravity. It is maintained through the contraction of skeletal muscles, coordinated by a series of stimuli of various nature and through continuous adjustment of neuromuscular type (7).

We can then define the posture as any position that determines the maintenance of balance with maximum stability, minimal energy consumption and minimal stress of the anatomical structures (7,11).

Key concepts of the posture can be summarized as follows:

- Concept of spatiality: position assumed by the body in the three directions of the space and the spatial relationship between the various skeletal segments;

- Concept of anti-gravity: gravity is the fundamental external force for posture adjustment, and the postural balance is a response to gravity;

- Concept of balance: relationship between the subject and the environment.

The subject adopts the most appropriate posture in relation to the environment and the mobility targets, in static and dynamic conditions. The ultimate purpose of the posture is therefore the maintenance of equilibrium in both static and dynamic conditions (12).

The balance is due to the interaction between different main and secondary anatomical structures. The main structures are vestibular organs, cerebellum, cerebral cortex and reticular formation, and the secondary are exteroceptors, (tactile and pressure) located under the foot, visual receptors and proprioceptors located in tendons, joint capsules and muscles (2,7).

The balance can be:

- Static: the ability of a body to maintain the static position. In this kind of balance, the spinal column is stretched upwards from the base of the sacrum, on the midsagittal plane, with three physiological curvatures which are formed along the line of the center of gravity.

- Dynamic: the ability of a body to maintain the stable condition during the different daily activities.

In both static and dynamic balance, the center of gravity is maintained in according to anatomic structures but with the minimal energy consumption, distributing the body weight throughout the skeletal system. In addition, the muscular system uses antagonistic isometric contractions that determine postural tone, responsible for maintaining the posture (2,7).

The posture is possible thanks to the interaction between the muscular system and skeletal system. From a functional point of view, the posture can be:

- Functional: characterized by absence of pain, normal muscle tone, absence of muscular tension, balance of kinetic chains and preservation of the harmonious relationship of skeletal segments in the three spatial planes.

- Non functional: characterized by pain, muscular dystonia, abnormal muscle tension, imbalance of kinetic chains and loss of harmony of skeletal segments in the three spatial planes (12).

From a purely motor function, the posture can be:

- Static: an active resistance to the dislocation caused by the action of the forces of gravity on the body segments.

- Dinamic: it maintains the balance through the synergistic action of active components (such as muscles), passive components (such as joints and bones), and control components (SNC, proprioceptive and exteroceptive systems, vestibular system) (7,13,14).

Posture control

The posture control is an isometric and motor behavior, which represents a stable starting point of the execution of the movements. The effectiveness of the postural control system depends on the availability and reliability of the information from the vestibular and somatosensory system. When any of these components is altered in a pathological way, the oscillation body generally increases and the activity of the postural muscles is increased in order to maintain a postural balance (15).

The posture may be regarded as the result of a large number of sense-motors integrated reflections, at different levels of the central nervous system, with an automatic and extremely precise adjustment (2,7).

The postural control is regulated by a complex system comparable to a black box, defined since the input and output functions are known even if it doesn't not know the processes with precision and the neuro-anatomical structures that determine input-output (8).

This system is better known as Tonic Postural System, and is a «cybernetic system», composed by an afferent system (sensory pathways) that transmits informations to a central computer (Central Nervous System-SNC) that (muscular system) is ultimately responsible for postural control thanks to an efferent-effector pathway (8,12).

To simplify the basic mechanism that regulates the posture, we could refer it to a simple reflex arc, (2,6) even if, unlike what happens with the reflexes, the postural movements are continuously influenced and improved by learning and by the exercise (16).

The information coming from the environment are received from the sensory systems, such as the visual system (by the retina), skin system (due to receptors situated under the feet), vestibular system, the Golgi tendon organs and muscle spindles (9,10,16).

These stimuli are transmitted to the higher centers, which include the brain, the cerebellum and the brain stem, through interneurons and motor neurons in the spinal cord. The informations, once they reach the central nervous system, are processed and recorded in the form of body image (knowledge you have of your body in a static situation and dynamic). After that they are transmitted to the muscles, where it takes the contraction of the muscles causing the displacement of skeletal levers and a consequent stabilization of the posture (2,7,9).

The input information is provided by the somatosensory system, which includes exteroceptive and proprioceptive receptors, and by the vestibular and visual systems.

The somatosensory input is generated by the sense organs localized at different levels:

- Muscular: supplied information by the muscle (sensitive to changes in length of the muscle bundles) and Golgi tendon organs (sensitive to changes in muscle tension).

Postural fluctuations cause light muscle strains and subsequent activation and response of the muscle spindles. Muscle proprioceptive information is particularly precise and discriminating.

- Visual-oculomotor: retina (paracentral and peripheral), transmit information relating to the movement of the visual field and detect the orientation of the head according to the perceived vision;

- Vestibular: in the control of posture is not involved the entire vestibular system. The semi-circular canals in fact are not involved in the control of posture, because the threshold of their perception is too fine to be controlled through the stabilometry. True vestibular receptors are otoliths that transmit information relating to the acceleration and deviation of the head and that play a role in controlling postural fluctuations.

- Skin: detects the bending of the foot related to the support surface, using the skin receptors, localized primarily at the level of the foot (9,10,13,14,16).

The output signal is represented by muscle. This is modulated and coordinated at the level of the central nervous system by complex devices that have as final target the striated extrafusal and intrafusal muscle fibers and is reached by motor neurons. The central nervous system thus becomes responsible for the muscle tone, that is, the slight tension that the striated muscles are at rest properly maintaining the positions of the relative parts of the body and is opposed to passive modifications of these positions (2,7).

Posture and stomatognathic system

Various elements of the stomatognathic system also participate to the regulation of postural orthostatic. The stomatognathic system consists of the maxillary and mandibular bones, that actively participate in maintaining the correct position of the skull with the flexors and extensors of the neck, the muscles above and below the hyoid, the muscles of mastication and the shoulder girdle.

Biomechanically it is considering a single functional anatomical complex cranio-cervical-mandibular. Several studies have shown that changes in mandibular position induce variations to the posture. It has been demonstrated that the mandibular position changes the electrical activity of postural muscles, especially paravertebral, and some experimentally changes in the plantar stance influence the basal muscle tone of the upper temporal muscles (9,17).

There is no doubt that certain stomatognatic skeletal features are accompanied by compensatory mechanisms of neighboring districts to the postural level (i.e. cervical spine, shoulder girdle) and probably of the not neighboring too (9,18).

The main causes that can lead to impaired function in cranio-mandibular relationship are: the tilting of dental bones, occlusal interferences (i.e. malocclusion), general disorders and musculoskeletal disorders related to the emotional sphere. Occlusal problems (such as malocclusion) are considered the main risk factor for dysfunction of the stomatognathic system (17).

The malocclusion is an erroneous arrangement of the teeth, which also includes an abnormal closing of the jaws, and a muscular balance problem in the closure of the mouth. As a consequence the jaw can assume a position slightly or seriously impaired when the teeth come into contact. Poor dental occlusion may be responsible for changes of the whole body postural alignment with changes in the spine in the frontal and sagittal plane, which in turn can affect even a breech level causing limb-length discrepancy. The dysfunctional resulting imbalance can be, in turn, responsible for acute and chronic pain states frequently caused by the temporomandibular joint district, cervical and lumbar. Malocclusion can also causes imbalance of the mastication muscles, which in turn disturb the closed kinematic chain of the stomatognathic and alter the posture, causing pain in the lower back. The existence of correlations between postural disorders and dental occlusion disorders is explained on the basis of functional and anatomical relationships between the masticatory system and the body posture adjustment systems (17).

If we consider the neurophysiology of the occlusion and the maintenance of the mandibular posture, we have at the level of the periodontium and the temporo-mandibular joint, the presence of a complex receptor system, consisting of:

- Non-nociceptive receptors that communicate strength, direction and speed of application of the forces on the crown of the tooth;
- Nociceptive receptors, which detect the presence of thermal stimuli, chemical and strong tractions and pressures that are exerted in the dental ligaments level;
- Muscle spindles and Golgi tendon organs;
- Mechanoreceptors responsible for the postural sensitivity that help to regulate the postural tone coordinating muscle activity that allows movement (19).

From a physiological point of view, nociceptive stimulus in muscles causes a stimulation of the motor neurons of the flexor and at the same time an inhibition of the extensor muscles.

Through this monosynaptic reflex we are able to move the limb that has received the nociceptive stimulus (19).

At the stomatognatic level, nociceptive reflexes originating from an abnormal contact between the tooth surfaces will result in a reflex flexor, while the postural reflexes respond with an extensor reflex.

If the stimulus is constant, the muscles move the lower jaw into a more comfortable position, but it will cause an alteration in posture. The postural reflex, as a reflection, is therefore an involuntary defense motion that causes a deviation from the initial movement (19).

Posturology

The discipline that deals with the scientific and clinical study of posture is the posturology (8).

In the last years the term "posturology" is increasingly used in non-conventional medicine to describe the discipline that studies the relationships between the various body posture and functional disorders, especially the chronic painful diseases as the headache, whiplash injury, fibromyalgia, and alterations in mental and bodily functions (15).

Posturology is important to recognize the anatomical and functional relationship between some postural attitudes and pathological conditions otherwise difficult to recognize (11).

Posturology is the way to study the posture from different points of view among which:

- Neurophysiological model, based on the study of postural tone and balance functions;
- Biomechanical model, that analyzes the relationship between body attitudes and gravity and that

studies the organization of the kinetic chains and static in relation to complex mechanisms antigravity and spinal and vestibular reflexes;

- Psychosomatic model (12).

Postural pathology is not a very specific disease with a specific cure, but it is a set of symptoms that may have been caused by visual, breech, oral, proprioceptive, vestibular and epithelial problems. The main symptoms of postural disorders are represented by headaches, pains in the spine level (such as neck pain, back pain and low back pain), pain in arms and legs, difficulty performing physical and daily activities. Postural abnormalities associated with these disorders may result from several factors including pathogenic traumatic injuries, inflammatory processes, congenital or acquired deformities, degenerative processes and tumors (9).

The postural analysis allows the therapist to visually evaluate the patient and to determine an ideal position. The ideal location be checked on three levels:

- The sagittal plane
- The frontal plane
- The transverse plane (9).

The main diagnostic technique used in posturology is the stabilometry, an apparatus used for the evaluation of disorders of balance, based on translating the mechanical oscillations of the human physiological gravicentrum into electrical signals, which are amplified, recorded and analyzed. The patient is made to stand on a baropodometric platform, and is invited to take different positions. Analyzing these positions with special methods, it is measured the stability of the posture (15).

In the last years a new and modern technique called spinometria is used. The digital spinometria is an apparatus for optical detection in three dimensions (3D) of the morphology of the trunk, based on the principle of rastereografy (of bright stripes grids) combined with triangulation algorithms. This technique is an excellent way for evaluating the shape of the spine as it reproduces and extent absolutely precisely (with an accuracy of 0.2 mm), the sagittal profile of the column. The spinometria is able to make accurate assessments of the vertebral curves by measuring the most important parameters biomechanical and postural. It also shows with sensitivity and precision the alterations that jeopardize the spine (5,6).

Current state of art

Currently there is much confusion about the posturology and its correlation with the stomatognathic system.

For example about the use of the stabilometro there is no scientific evidence of the diagnostic reliability of stabilometro.

In fact this instrument is capable of measuring big changes in patients suffering from balance disorders of neurological origin or from relevant neuromuscular alterations, but there is not a clear evidence that it is reliable in the measurement of small postural changes (15).

Numerous contrasts are linked to the correlation between posture and stomatognathic system. According to Ciancaglini et al. (20), the correlation between the correction of occlusive and temporomandibular joint disorders (TMJ) and the improvement of postural problems symptoms is well supported by scientific and experimental evidence (20).

In particular this studies and the Consensus Conference of 2009 show that the set of anatomical, clinical and experimental observations are in favor of a correlation between postural disorders of the spine and TMJ disorders occlusal (20,21).

A different opinion has been proposed by Sandro Pall. In the DentalAcademy.it online magazine of January 21, 2016, he wrote that:

"*The occlusal therapies cannot be accepted as a therapy to treat postural problems as well as postural or physical therapy treatments cannot be used to treat occlusal problems.*"

The debate is still not over and therefore further studies are necessary to be able to confirm one or the other argument.

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