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THE INFLUENCE OF VISION ON POSTURE

MASTER THESIS

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ABSTRACT

Thesis is written in English on 45 pages. It contains 28 figures, and 40 references.

The aim of this thesis was to assess the efficiency of the optometric treatment in the change of the posture. 11 patients were tested using the stabilometric computerized platform before and after vision training. After the treatment and when the eyes were opened, the weight distribution were more balanced in anterior-posterior direction, the centre of pressure moved closer to the theoretical centre and its speed sway, length and area became smaller. When the eyes were closed, no statistically significant changes were observed before and after the treatment. Thus, improvement of visual quality can directly affect the posture and balance of the patient.

Key words: visual training, posture, stabilometric computerized platform, centre of pressure, weight distribution.

ANOTĀCIJA

Maģistra darbs ir uzrakstīts angļu valodā uz 45 lapām. Tas satur 28 attēlus un 40 literatūras atsauces.

Darba mērķis bija izvērtēt optometriskās ārstēšanas ietekmi uz stājas izmaiņām. 11 pacientiem tika veikti mērījumi ar datorizētu stabilometrijas platformu pirms un pēc redzes treniņu veikšanas. Pacientam stāvot ar atvērtām acīm, pēc redzes treniņiem svara sadalījums bija sabalansētāks priekšēji-mugurējās ass virzienā, spiediena centrs nobīdījās tuvāk teorētiskajam centram, kā arī svārstību ātrums, amplitūda un laukums samazinājās. Pacientam stāvot ar aizvērtām acīm, nenovēroja nozīmīgas izmaiņas pirms un pēc ārstēšanas. Līdz ar to, redzes kvalitātes uzlabošana var tieši ietekmēt pacienta stāju un līdzsvaru.

Atslēgas vārdi: redzes treniņi, stāja, datorizēta stabilometrijas platforma, spiediena centrs, svara sadalījums.

TABLE OF CONTENT

INTRODUCTION

Balance means the optimum condition in which the person assumes a posture or a series of ideal postures depending on the environmental situation in that particular moment and for foreseen motility. Balance is an extremely complex function, constantly influenced by the force of gravity and by voluntary and involuntary movements of the head and body. It involves many systems and sensorial and motor strategies. Maintaining the balance means to compensate movements automatically through the reflex chains and under the control of cerebral stem. It depends on the information given by the different sensorial systems. The most important are:

- proprioceptor in the muscles that show on the variations of muscular length/tension;
- vestibular receptors;
- visual system that transmit information about movements of the visual field;
- pressure receptors in the feet.

Balance and posture problems were observed in patients having gnathological problems (affecting mouth movements) (Baldini, et al., 2013) from simple bruxism to maxillo-facial traumas of various nature. They complain of major disorders that may be more or less painful and able to worsen the personal well-being creating headaches, mandibular clicks, sleep disorders, tinnitus, dizziness, problems with walking and driving, postural difficulties at work, cervical disorders, vertebral disorders, disturbances in focusing and doubled vision. These problems may exist for a longer time neither treated symptomatically nor pharmacologically. They create social and economic discomfort. They create also additional problems: visual disorders, malocclusion, alterations to podalic support, tendon muscle inflammation, cervicalgia etc. It must be considered also that postural changes due to malfunction of the visual system, so not only the view, can also be related to learning disorders, and abnormal behaviour in the classroom, fatigue, listlessness, hyperactivity, and lack of concentration.

The objective data derived from postural examination can help to evaluate the posture and stability and the effect of various sensorial systems. Thus, the effect of visual system can be evaluated by performing measurements with closed eyes and with opened eyes. In addition, optometrist can identify functional disorders of vision that can create postural compensation and relate to postural abnormalities. Visual treatment can affect the visual posture and improve the stability and posture of the patient.

The aim of this thesis was to assess the efficiency of the optometric treatment in the change of the posture. The variations in postural examination using stabilometric computerized platform were compared before and after optometric treatment in 11 patients.

The tasks were:

1) to compare the weight distribution changes before and after optometric treatment,

2) to compare the changes in the centre of pressure relative to the theoretical centre before and after optometric treatment,

3) to compare changes in sway (oscillations) of the centre of pressure and its parameters before and after optometric treatment.

The novelty of this thesis is that it is known that the vision changes the posture. But usually the main treatment is based on the posture changes by involvement of osteopaths, dentists, gnatologists, and others specialists directly working on the posture. Optometrists are rarely involved. Therefore, this study can be a base for an interdisciplinary exchange with the aim of obtaining, over time, a shared clinical protocol for the analysis and treatment of postural disorders, in which the optometrist is a reference for the study and the treatment of vision.

1. REVIEW OF LITERATURE

1.1. Definition of posture

Posture results from an activity involving several sensory organs, and for this reason, it is treated by more than one specialist who will come together in a common diagnostic and therapeutic direction with the aim of restoring the best balance, both static and dynamic, and the highest degree of security possible. The definition of posture is also characterized by the period in which it was stated and by the professional qualification of its author.

The human posture is the position of the body and spatial relations among its anatomical segments that keep the balance under dynamic and static conditions (anti-gravity muscle function) according to the characteristics of the environment and purpose motor act that performs. It is the attitude that we take in relation to sensory stimuli. Sensory information is of great importance for the formation of strategies and postural patterns. The stimulus will help determine the quality of the motor activity produced after being transported by external and proprioceptive sensors to the central nervous system and elaborated in accordance to the experience previously acquired.

The position of the head and neck can modify the postural pattern of everyone (Edwards, 1946). It is certain that the posture intervenes in the regulation of the circulation, blood pressure, cardiac rhythm. It is also related to the type and depth of respiratory movements as taught and supported by Ling's school, and in particular by the Portuguese school of physical education (Gagey, & Weber, 2000). Posture is also communication; it develops the psychosomatic aspect of posture treated by different authors and clinicians.

To maintain defined position of the body in space, posture is using a large percentage of energy produced by our body. This maintenance is up to the muscles that continually contract and relax by organizing the delicate precise and unconscious process of postural retention. This constant body fluctuation, given by the search for balance between gravity and muscle response, is realized around the centre of gravity and is dynamic posture. It is realized through self-correction mechanisms that act according to the sensory information, the postural reactions accumulated in our memory, the efficiency of muscular action, the ability of the joint movement and the coordination of the central nervous system, to be efficient in the tonic postural system (TPS) and work as cheaply as possible. The multisensory feature involves the intervention, the interest of different afferents, which to build the posture. Each one has a specific role and competence, which develops and strengthens, in the neurological context, with the passing of time. Every sensory afferent draws body posture and movement, but it is also each person's own response to stimuli, which is the result of different motor, neurological and emotional experiences.

1.2. The postural tonic system (PTS)

It is a very complex set which involves all the afferents of the central and peripheral nervous system especially the eyes, foot, skin, muscles, joints, the stomatognathic apparatus (occlusal system and language), and the inner ear. The body-scheme is the result of processing, and the mental representation that these information undergoes and body schema management is based on behavioural parameters established by experience. The body-scheme rules postural balance and is based on visual, vestibular and somatosensory inputs. (Guez, 1991). At the same time, one must always consider that the mind deals with "simplified", individual response to a mechanical stimulus, making subcortical response, learning just the motor patterns and therefore behaviour. And this is an advantage, in terms of energy management and efficiency in motor performing, providing that these schemes remain efficient, otherwise, the inefficiency creates adaptations that are intended to reduce energy expenditure and avoid excessive nociceptive phenomena, which would affect, memory, psyche, and behaviour (the nociceptive event is memorized). Postural balance remains largely thanks to the visual and vestibular system information, which together keep in balance the head position because visual and vestibular information have in common most neurological pathways.

The analysis of the variance (ANOVA) in this type of studies confirm the existence of a significant and clear correlation between the vision and postural control (Edwards, 1946). This conclusion is reached by reasoning that vision is a fundamental component of PTS and that the exclusion of vision makes it very difficult for the system to control posture (Baldini, et al., 2013). If the visual system is deficient or malfunctioning in the motor area, the neck muscles takes the task of overcoming this deficiency. Certainly, this solution is not the most efficient and economical and results in compensation for the cervical vertebrae, oculomotor system, accommodation system, and shoulders.

If most of the visual field is moving, it is because the head is offset compared to the field of vision, providing information integrating what is provided by semi-circular channels, and is used in the same way to generate postural and oculomotor responses. For this reason, the postural system must be informed about the eye's position in relation to the head, the head within the body and the body in relation to the space around us, this information will tell us how and where the body is located (Carpenter, & Reddi, 2012).

Clinical studies (Krishnan, & Aruin, 2011) demonstrate that visual information in normal subjects plays more significant role in walking process than proprioception, while proprioception becomes more efficient in subjects with visual problems in improving postural control. However, while the contribution of somatosensory and vestibular systems to maintain upright position is documented in the literature, the role of the visual system is less understood despite its importance (Wade, & Jones, 1997). This may be because the obtaining and processing of visual information is influenced by many factors within humans themselves and environment, as well as by the interaction between the two. For example, visual acuity, contrast sensitivity, and depth perception play a significant role in how the human being can see the object clearly. Environmental factors such as lighting in the room also affect the way people see the surrounding world. For example, the previous literature has shown how humans demonstrate reduced ability to control posture under soft light conditions (Lord, & Menz, 2000; Owsley, & Sloane, 1987).

When human maintain vertical posture, the central nervous system (CNS) uses two types of adjustments in the activity of the trunk muscles and foot. The first, anticipatory postural adjustments (APA) (feedforward) (Massion, 1992) are associated with activation of the muscles before the real disturbance of the balance. The role of APAs is to minimize the negative consequences of a planned postural perturbation (Bouisset, & Zattara, 1987). The second type is the activity of the compensatory postural adjustment muscles is the reaction (feedback) (CPA) that takes care of the actual balance disturbances that compensate for sub-optimal efficiency of APA. These reactions are started by sensory feedback signals (Alexandrov, et al., 2005; Park, et al., 2004). It has been shown that the increased presence of APA increases postural stability (Santos, et al., 2010a; Santos, et al., 2010b) and that the vision plays an important role in the generation of APA (Krishnan, & Aruin, 2011; Mohapatra, et al., 2011). In particular, APA is observed when subject fixates the object and suddenly closes and opens the eyes (Lacquaniti, & Maioli, 1989). The role of vision in normal conditions is therefore crucial to provide constantly updated information on the position and movements to the CNS of body segments and its relationship with the environment while maintaining the balance. So, when the subject is standing with eyes closed, postural oscillations increased by 20-70% compared to walk with the opened eyes (Lord, et al., 1991; Magnusson, et al., 1990; Paulus, et al., 1984). In addition, it has been shown that modifying visual information by moving visual field causes a strong sense of movement resulting in a significant increase in body oscillation (Wei, et al., 2010). Previous researches provide many proofs about the importance of visual information in vertical posture recovery after an external perturbation applied to the body (Bardy, et al., 1999; Clement, et al., 1985; Schmid, 2007).

1.3. Proprio and external receptor activities involved in posture (summary)

To understand what and how many mechanisms may be involved in determining posture, it is necessary to briefly describe their location and function. Spinal reflexes produce coordinated contractions of muscle groups, and skin reflexes produce complex movements that perform protective and postural functions. The sensory stimuli that evoke spinal reflexes come from the muscle receptors, joints and skin and the circuits that mediate the responses of spinal reflexes are located within the spinal cord (Kandel, et al., 2007).

1.3.1. Proprioceptive and kinaesthetic sensitivity

The proprioception is accomplished by means of two modes: the sense of static position, and the sense of movement (kinestesia) of the limbs, and of the body, which occurs independently of the sight. These perceptions are important for monitoring the movement of limbs like during manipulation with objects with different mass and shape and for maintaining straight posture (Kandel, et al., 2007). The spatial orientation information is also learned by combination with other sensitivities such as sight and touch, the sense of balance during development. The proprioception from a point of view strictly is musculoskeletal, this term used to describe the sensory inputs which originate in the course of movements guided centrally by specific structures: the proprioceptors. Their main function is to provide feedback on the movements of the body, in other words to point out, instantaneously, what movements the body is doing. Proprioceptors are nerve endings that send information to the nervous system; the stimuli are perceived by specific receptors in muscles, tendons and joint capsules. These terminations generate nerve impulses that are transmitted to the spinal cord and from here may remain in the spinal cord itself, for the determination of spinal reflexes (reflex arc) or reach other parts of the spinal cord or brain for the determination of specific functions (see Figure 1.1) (Kandel, et al., 2007).

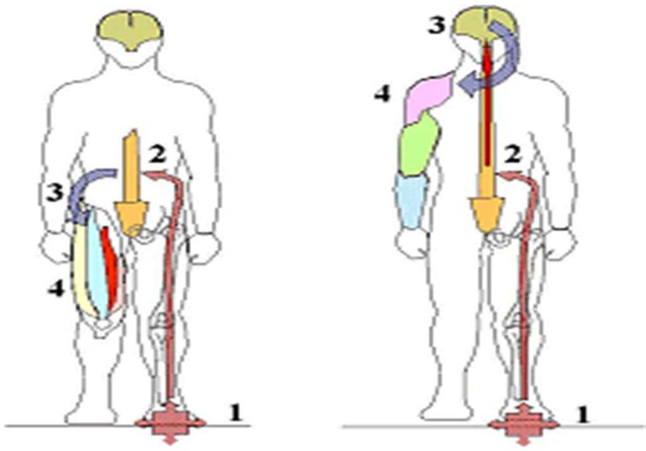

Figure 1.1 Nerve impulse transmittance for the determination of spinal reflexes (reflex arc, figure to the left) and of specific functions (figure to the right) (https://posturaltrainer.wordpress.com/2011/05).

Proprioceptors have an important function in controlling skeletal muscle contraction and through this control is performed most of the physical functions of the body.

1.3.2. Proprioceptive mechanoreceptors

There are various receptors. One of the receptors is muscle spindle (distributed in the body muscle). They control the stretching muscle reflex by adjusting the tone: if a muscle is suddenly elongated, the median part of the neuro-muscle spasm is stretched and this results in immediate signal delivery to the spinal cord. These signals excite motor nerve cells that control skeletal muscle fibbers immediately surrounding the melt. Therefore, sudden muscle stretching results in a reflex contraction that automatically opposes stretching. This function serves to "dampen" the changes in muscle length that is to prevent the length of the muscle from changing too quickly (Kandel, et al., 2007).

The second receptors are the Golgi tendon organ. They oversee the tendon reflex, or inverse stretching, which detects the magnitude of its tension and sends that information to the spinal cord and from it to the brain. The information in turn is used in nerve centres to precisely adjust muscle tension in relation to functional needs. If the organ detects an overload, it may cause the muscle to stop working to prevent the risk of damage. This factor causes release. They are slow adaptation structures, "downloading" information for long time related to the reactions which they are appointed. They are found in the ligaments associated with the joints and provide information regardless of the level of muscle contraction in order to inform the body about the joint position, moment by moment, regardless of muscular activity (Kandel, et al., 2007).

Other receptors are Ruffini's corpuscles. They are presented in the deep layers of the dermis, the subcutaneous tissue, and in the articular capsules. They are slow adaptation receptors and transmit the signal as long as the stimulus is presented, are not affected by the variation in the stimulus intensity. At the skin level, they are sensitive to stretching of the skin, nails, coarse tactile sensitivity and temperature changes (particularly they have maximum sensivity from 37° to 40°). At the articular level, they respond to muscle contraction that, with movement, change the status of capsular tension. In addition, to allowing positional maintenance, they also indicate the direction of movement (Kandel, et al., 2007).

1.3.3. External receptors

External receptors are responsible for the discrimination of the surrounding world through the main sensory organs, which send information to the CNS. Here we can divide three main senses – tactile, sight, and hearing.

Tactile localization and surface pressure allows to appreciate the shape, material, and surface characteristics of things and to locate the point of the touched body, as well as also the movement of light objects on the body surface or vibration. Thermal and localized pain discrimination allows to distinguish the thermal qualities of the objects and to localize painful stimuli. The muscles get information even from the skin receptors like described in Figure 1.2. Neurologists distinguish tactile sensations in two large groups: epicritic and protopathic. Epicritic sensation (where epicritic neurons are involved) relates to tactile form to detect light skin contacts and skin location (topognosia), recognizing vibratory stimuli by amplitude and frequency, analysing spatial and the tactile discrimination of two points. Epicritic sensivity varies according to the skin area involved, and is directly proportional to receptor density, recognizing the shape of objects held in the hand or getting in skin contact (stereognosia) (Kandel, et al., 2007) (see Figure 1.2). The protopathic sensation (where prothopatic neurons are involved) include pain and thermal sensitivity. They are also involved in sensation of itching and tickling. To activate protopathic neurons, larger area and stronger stimuli are needed (Kandel, et al., 2007). The main tactile receptors are: Meissner's corpuscles, Merkel's disks, Pacinian corpuscles, Ruffini's corpuscles.

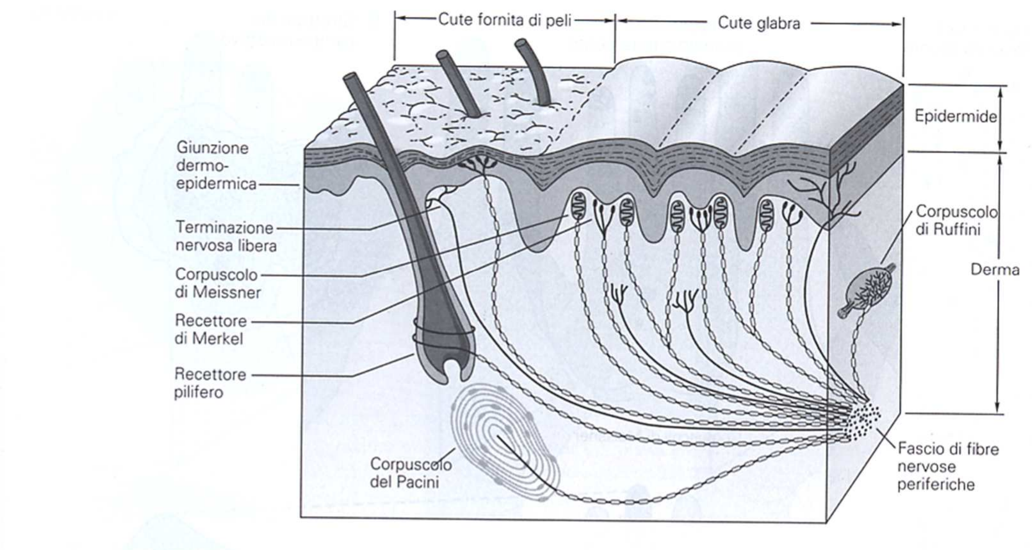

Figure 1.2 Localization and morphology of the mechanoreceptors of the skin (of the human hand) involved in the tactile sensation. The receptors of the glabrous skin are Meissner's corpuscles, which are in correspondence of the dermal papillae, the Merkel's disks arranged between the dermal papillae, and free nerve endings. The receptors of the skin hairs are provided with the hair receptors, the Merkel's disks (which have a slightly different morphology than those of the glabrous skin) and free nerve endings. Subcutaneous tissue receptors underlying both the skin glabra that are supplied with hair are Pacinian corpuscles and Ruffini's corpuscles. The receptor's functional properties depend on their structure (Kandel, et al., 2007).

The organ involved in sight is the eye – the organ that strongly influences the postural tone system. It behaves both as an external receptor (acquires information from the outside through the retina) and as a proprioceptor (proprioception is linked to the activity of the extraocular muscles and muscles in oculo-neck pathway). It has a significant role especially if considering the visuo-vestibular report for what concerns the spatial location of the body and space in relation to the individual vestibular ocular reflex. In the postural sphere, the "ocular receptor" can be considered as causative or adaptive.

Hearing captures the frequency, amplitude, distance, and spatial location of vibrations (noises and sounds). It has a nociceptive reflex and has a functional dominance as in the vision. It demonstrates a robust protopathic component, and, above all, is distinct from all other sensitivities; it is perceptive organ of language (Dellabiancia, 2016).

The remaining senses are those of smell and taste, senses that are not closely connected with motility and yet play a significant role in determining the emotional-affective state linked to the primary instincts (hypothalamus). For this reason, they can achieve a meaning that is certainly important in motivation of movement, but in primordial states or vegetative phases of relationship functions. The set of receptors constantly sends information to the central nervous system. The latter integrates and processes the message and sends efferent impulses to the effectors the, muscles, with the goal of economical, functionally effective and coordinated movement that preserves the biological integrity of the tissue (see Figure 1.3 and Figure 1.4).

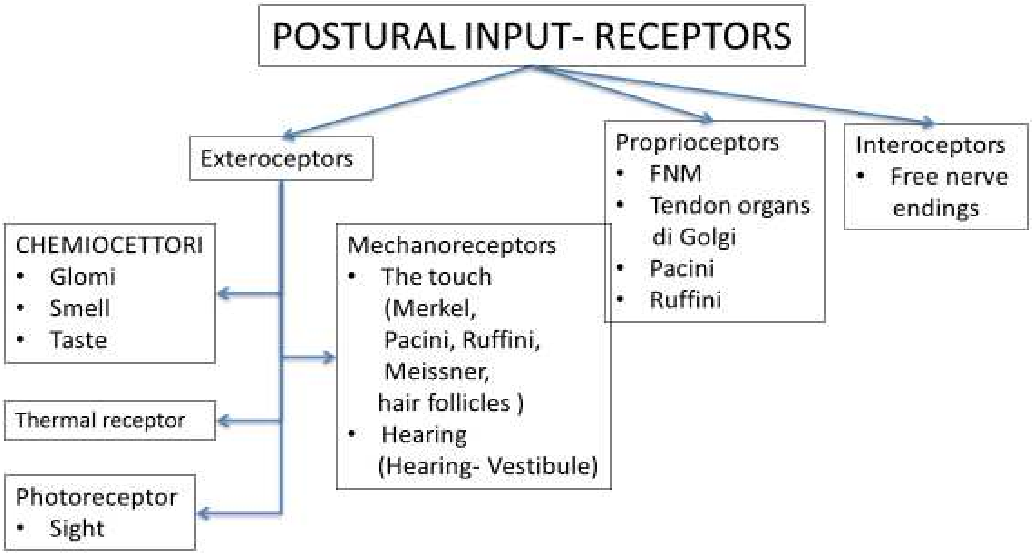

Figure 1.3 The diagram of receptors involved in the maintenance of the posture (with a courtesy of Dr. Emanuele Ruggiero, Italy).

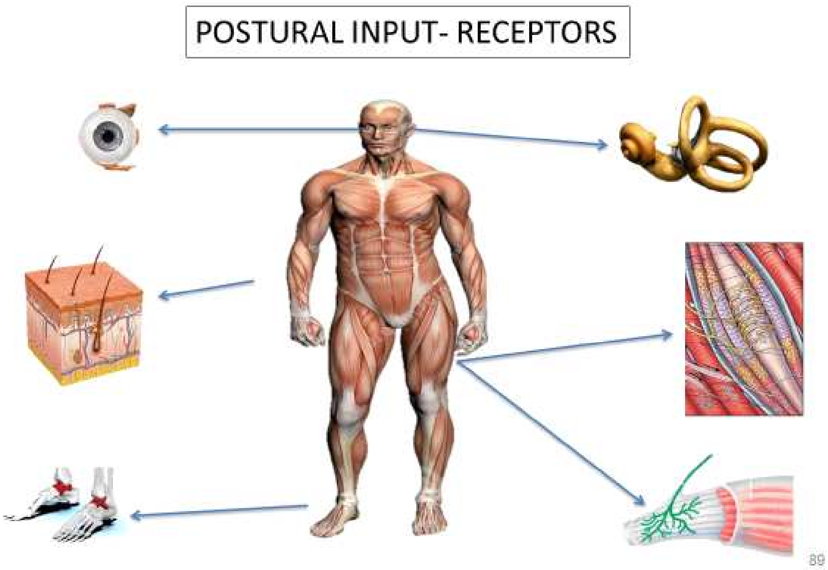

Figure1.4 The location of the receptors in the human body related to the maintenance of the posture. (with a courtesy of Dr. Emanuele Ruggiero, Italy).

Under the postural aspect, they participate in the formation of behavioural and postural schemes. The eye is no exception, but having a dual receptor value also has greater importance in this regard.

1.4. The connective tissue

In addition to being the support for the elastin, the connective tissues are also the matrix that ensures the mechanical union of all the systems that constitute the human body. Its function is of primary importance since its system constitutes the intimate structure on which all structures with specific micro and macro functions are based (Furlan, & Mossi, 1999). The connective tissue is a mesenchymal-derived; mesenchyme is the support fabric and filling of the embryo. With the subsequent development of the embryo the mesenchyme will differentiate into bone tissue, ligament, fibrous, tendon, fascial, and aponeurotic tissues. According to a scheme, that perfectly connects every cellular structure with the other, close or distant ones that are. Connective constitutes, with exceptional differentiation into tissues with different specificities, constitute the "support frame" for each segment or body structure.

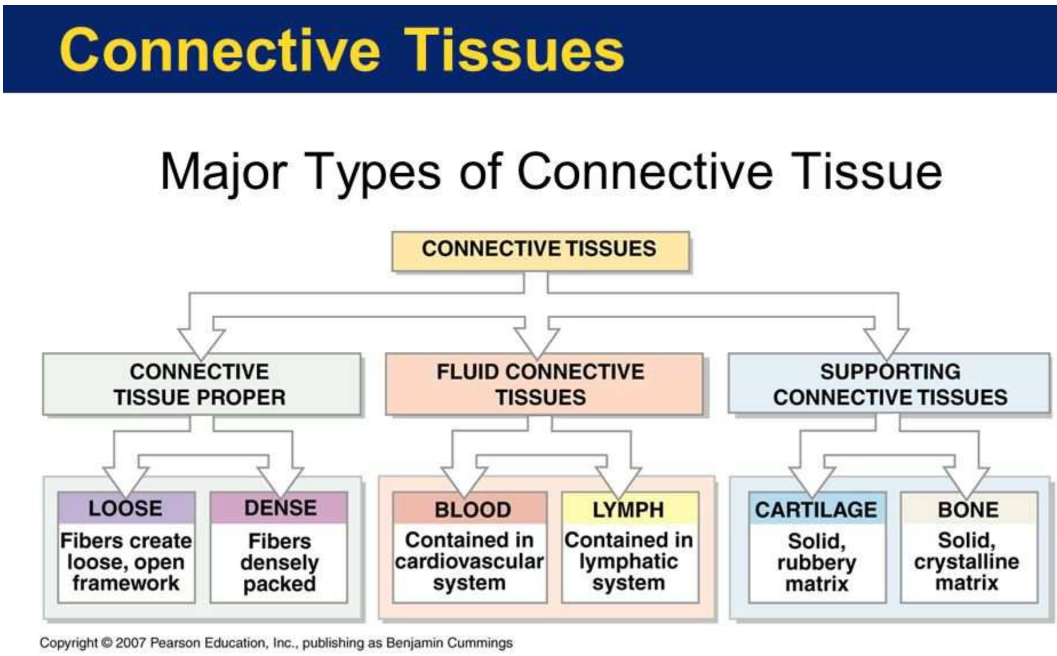

Figure 1.5 Diagram, demonstrating principle types of connective tissues (http://slideplayer.com/slide/9324352/).

Depending on its specialization and functions, the connective tissues are divided into various types: compact shapes and organized and soft composition. The presence of connective tissue, although with different nomenclatures, is found in every region of the body. From a type of connective, it passes to another by means of an inert substance, which confers a progressive continuity. The connective tissue proper is divided into: soft, dense, mucous, pigmented, elastic, reticular, cartilage, adipose (Furlan, & Mossi, 1999) (see Figure 1.5).

The bands are part of the connective tissues. Based on their morphological characteristics, they are classified as connective dense and structurally regular, oriented in the direction of the muscle or tendon movement, particularly in the tendons, there is a greater regularity of the structure.

Muscle bands and aponeuroses (thin fibrous band that wraps around the muscle and creates continuity with the tendon) participate in the coordination of both musculoskeletal and visceral movements by dividing muscle structures into septums and making sure that every muscle works for the same task in a synergistic way with others (Furlan, & Mossi, 1999). The nerve structures contained in each compartment are kept in tight mechanical relationship with the tissue portions to which must provide stimulations. The distribution of the whole is thus able to ensure better quality transmission of impulses. The role of the nerves is accomplished by the neuromuscular receptors such as Golgi tendon organ, Pacinian corpuscles, and Ruffini's corpuscules (Furlan, & Mossi, 1999).

The role of the fascial system of the organism is very complex and articulated. It is useful to make a breakdown based on primary or basic functions: mechanical function and metabolic function. They are completely different among themselves, but complementary and interdependent.

The mechanical role includes following functions: postural stabilization, support, entrapment coating, mechanical power transmission, coordination of forces directed to the muscle groups, and protection. The metabolic role includes the functions of: tissue nutrition, diffusion of substances for the proper metabolism of the tissues. Collection and disposal of liquids is not otherwise channelled resulting in the elimination of catabolites, intake and storage of excessive nutrients in the form of fat. These activities are always related to the fascial structures. Their proximity to organs, tissues, and individual cells, is able to transmit the mechanical traction and a subsequent relaxation sufficient to induce the mixing of liquids guarantor proper homeostasis also in the smallest cell level. To ensure this role, an organization is needed that never allows a break in its continuity and so that it can be uniformly placed from the surface to the depth, reaching even in the smallest bodily districts.

It should be added that connective tissue is one of the sites of the first immune responses to any kind of external aggression, as the cells that make up the connective tissue directly participate in the immune functions. This answer is the result of a coordinated and integrated activity carried out by a different set of cells that are housed in the fascial tissue matrix: T lymphocytes, B lymphocytes, natural killer cells, monocytes, and macrophages

1.5. Connective muscle chains

In posturology, osteopathy and physiotherapy, you often hear about the muscle-connective chains. To better understand the totality of postural dynamics is only right to mention these structures. The muscular chains can be defined as the set of muscles in the body that work synergistically. Such synergy is dispatched thanks to the intimate anatomical arrangement existing between the muscles and the fascial system, connective tissue, and collagen. (Furlan, & Mossi, 1999). The concept of "muscle contraction chain" was introduced in osteopathy and subsequently resumed and expanded in postural gymnastics.

The muscle spindle can activate the upper nervous systems and develop new operating patterns. Often these adaptations are outside the physiology for compensation put in place by the body to eliminate any stress can cause pain. (Furlan, & Mossi, 1999) If we consider our posture as a continuous swing of balances and imbalances aimed at maintaining the verticality. It can be explained because, even in the presence of slight anomalies, our postural balancing system has to make large-scale corrections both for maintaining static posture (the stand upright) and dynamic (walking). The fascial component adapts to the situation by hiding the primary cause of the problem so as to cancel the original nerve influences a little comfort or pain situation. This fact allows to lighting the last compensation the body has created. And this results in the “pain symptom” that, if eliminated without the suppression of the primary cause of malfunction, will be re-triggered at the first opportunity. The pain symptom is the last sign of a series of adaptations that connectivity compensatory capacity has progressively created, modifying the body schema, which remain silent until the last adaptation can no longer be compensated.

1.6. Neurological representation of the visual system (summary)

As I explained above, the eye works as both external receptor and proprioceptor. Activity, for this second characteristic, through the motion of extra ocular muscles, and through activation of muscular sensors described earlier, informs the central nervous system of the position and direction taken by the body. This kind of afferences is capable of generating anticipatory stimuli of a motor act, which may or may not occur, depending on the choice and the circumstances. The brain plans a gesture on the basis of visual information, and also of the eye muscle. Thus, we can say that the muscular activity of the eyes joined the muscles dedicated to movement, so called, proprioceptive muscle-connective chain.

A variation of muscle tension determines a variation of general muscle-connective chain. Visual, tactile and muscular sensation tells us about the existence of the various parts of our bodies. However, beyond this, we have an immediate conscience that our body exists. We know the position of points of the body, example the nose, even when the afferents somatosensitive of these parts of the body are anesthetized. We have for this the body schema, which is not an innate structure or a fixed and static image, but on the contrary is a dynamic structure, in continuous adaptation, dependent on the maturation of the nervous system, from the psycho-emotional experience, the level of perception, sensorimotor and processes made possible by experience and postural and motor learning.

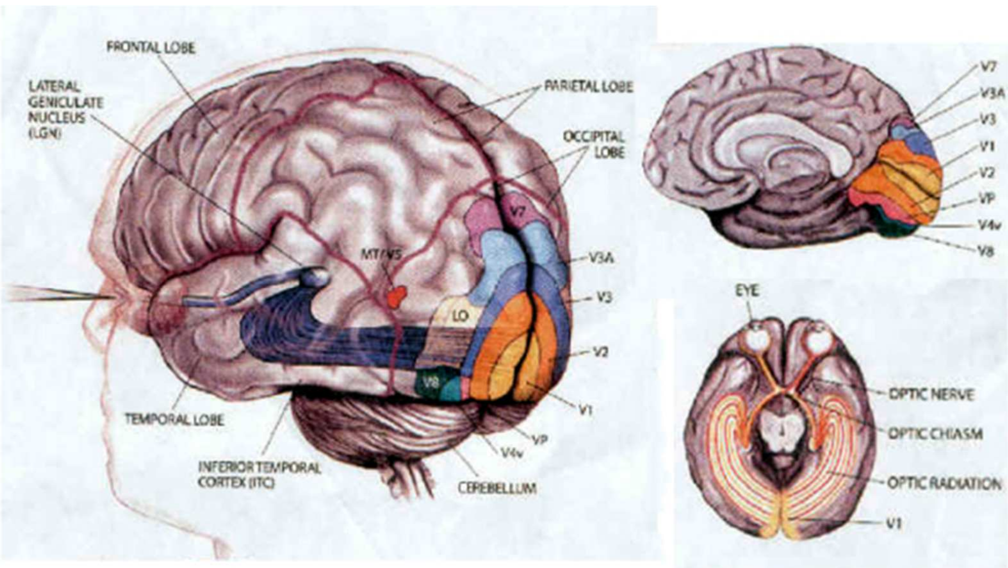

Figure 1.5 Visual pathways

(dpurb.com/2014/08/19/essay-biopsychology-vision-the-ventral-dorsal-stream/)

The visual system is strongly represented in the brain; we can say that under physiological conditions, the brain is made to "see." There are many areas of the brain related to the visual information, in direct or indirect way, each motor act is designed by an act of visual type. 4 out of 12 cranial nerves are directly related to visual performance: the 2nd optic, the 3rd oculomotor, the 4th trochlear, and the 6th abducent. Two cranial nerves are related indirectly:

the 5th trigeminal, the 7th vestibular. Also, as noted, many brain areas are involved visually: motor, memory at various levels, associative areas, spatial dorsal localization areas, ventral semantic recognition. In addition to the visual areas V1, V2, V3, V4, V5, and all areas involved with incoming visual information from the retina to the visual cortex (see Figure 1.5 and Figure 1.6).

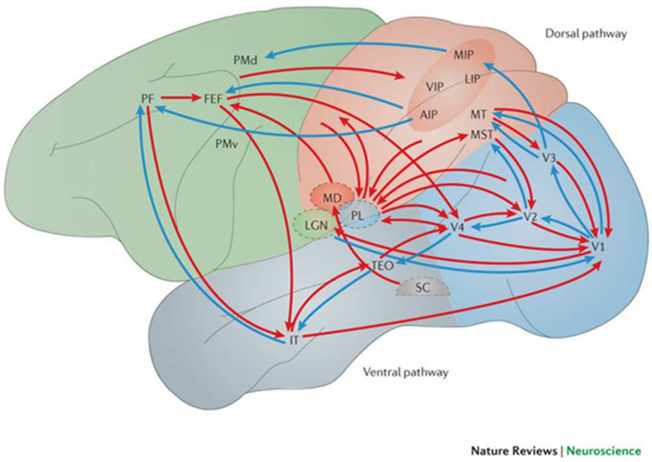

Figure 1.6 Visual pathways (Gilbert, & Li).

In Figure 1.6, processing visual information involves feedforward connections across a hierarchy of cortical areas (represented by the blue arrows). The visual cortical pathways begin in the primary visual cortex (V1), which receives subcortical input from the lateral geniculate nucleus (LGN). The feedforward connections extend through a ventral pathway into the temporal lobe and through a dorsal pathway into the parietal cortex and prefrontal cortex (PF). Matching these feedforward connections are a series of reciprocal feedback connections (represented by the red arrows), which provide descending top-down influences that mediate re-entrant processing. Feedback is seen in direct corticocortical connections (those directed towards area V1), in projections from area V1 to the LGN and in interactions between cortical areas mediated by the pulvinar (PL). Information about motor commands, or efference copy, is fed to the sensory apparatus by a pathway involving the superior colliculus (SC), medial dorsal nucleus of the thalamus (MD) and frontal eye fields (FEF). In addition to direct reciprocal connections, for example from area V2 to area V1, feedback can cascade over a succession of areas, for example, from the PF to FEF to area V4 to area V2 to area V1. As outlined in this Review, diverse information is conveyed across these pathways, including attention, expectation, perceptual tasks and efference copy. AIP, anterior intraparietal area; IT, inferior temporal area; LIP, lateral intraparietal area; MIP, medial intraparietal area; MST, medial superior temporal area; MT, medial temporal area; PMd, dorsal premotor area; PMv, ventral premotor area; TeO, tectum opticum (Gilbert, & Li).

Changes of the visual component can be caused by multiple reasons: optical, refractive, or neurological. Thus, visual problems can cause postural disorders, in fact, excessive tension of the extraocular muscles (induced by prisms or by non-centred lenses) can cause automatic compensating rotations of the head causing an incorrect posture of the head (abnormal head posture AHP). Therefore, a loss of visual alignment automatically and unconsciously determines the rotation and/or inclination of the head to have a clear vision. However, over time, such a change in the postural attitude of the head will cause a state of muscle hypertonia with intervertebral disorders, followed by hypomobility segmental, and if this situation continues over time one will have degenerative lesions. Disorders of the visual function determines, therefore, a chain of responses from the motor component (postural adaptation) with postural alterations of the head, and possible repercussions to the foot, which compensate by changing the support thus triggering a vicious circle which leads to a progressive deterioration of the situation. On the other hand, postural alterations due to proprioceptive and external receptive problems, or problems of the stomatognathic apparatus, can in turn cause visual problems or coexist with the latter. Therefore, postural alterations of any origin can alter the mechanism of vision, which is the result of synergic action between various muscles and neurological input responses.

There are studies that highlight the many relationships between the oculomotor system and the stomatognathic apparatus. The oculomotor system comes from the occipital somites along with the muscles of the tongue and sub-occipital muscle (Sadler, et al., 2013). These structures are functionally tied and cooperate to handle the head and neck position (Bilello, et al., 2009). The trigeminal system representing the connection between these somitic structures and those derived from the branchial arches, gathering proprioception from both somitic structures and oculomotor muscles (Testut, & Latarjet, 1971). The trigeminal system is also a part of the "oculo-cefalogira" (oculo-trigeminal-cefalogira) (Testut, & Latarjet, 1971), contributing to neuromyofascial regulation of the craniocervical-mandibular rest position. Many studies have evaluated the presence of connections between trigeminal and vestibular nuclei and the superior colliculus (Monaco, et al., 2013). Clinical experience in dental practice claims that some skull-mandibular characteristics can be related to both eye functions and functional defects (Monaco, et al., 2004; Pradham, et al., 2001). The trigeminal nerve is the largest and most complex of the twelve cranial nerves. It supplies sensations to the face, mucous membranes, and other structures of the head. It is the motor nerve for the muscles of mastication and contains proprioceptive fibres. On the other hand, some anatomic studies related the trigeminal nuclear complex to several other nuclei of the brainstem linking trigeminal function to facial, hypoglossal, cochlear functions vagal/parasympathetic function and for this review to collicular and oculomotor system (Manni, et al., 1989). This integration justifies the functional union between neck, head, tongue and vegetative responses induced by postural. The eye also affected by swallowing alterations both about the motility of extrinsic muscles that with regard to the visual ability. There is evidence suggesting the influence of trigeminal stimulation on ocular convergence and the motility of extrinsic musculature (Crocellà, 2008). There seems to be a particular affinity between spot palatine (positioned on the palate behind the incisive teeth) and ocular motility, of abducent rectum in particular. Even the visual function can be affected indirectly by the lingual function. The ciliary muscle receives its innervation from the ciliary nerve that originates between the third and the first cervical vertebra. It was noted that the first improvements during the rehabilitation treatment of swallowing are evident at the level of the cervical district. It is extremely likely that cervical change, with a recovery of physiological lordosis, can be the reason of the visual improvement, which has been valued at about 40% of patients with eye correction (Edwards, et al., 2009). In addition, Meyer and Baron (1976) demonstrated connection between the oculomotor nerves, vestibular, trigeminal nerve and accessory through the fasciculus longitudinal medialis.

2. RESEARCH

2.1. Instrumentation

To perform this research, the stabilometric computerized platform, Postural Health Station (DL Medica SpA, Milano, Italy) was used (see Figure 2.1). With the stabilometric computerized platform, it is possible to execute the monitoring of rehabilitation and drug therapies (such as non-invasive method suitable to evaluate the influence of some drugs with an objective on the CNS). It serves to study the postural strategy of the patient and what movements it must do to maintain the balance. The stabilometric platform is the instrument capable to scientifically evaluate such behaviour. Some platforms have a feedback for treatments with an interactive interface.

The stabilometric computerized platform used in this research is provided with piezoelectric transducers or sensors within an internal circuit capable of identifying the changes in pressure and converting it to an electrical charge. The basic functions of this platform is to allow posturometric and stabilometric measurements. Posturometric measurements allow to assess the centre of the pressure (COP) during standing. In addition, posturometric measurements allow to measure the weight distribution and the degree of asymmetry between the two feet. The stabilometric measurements allow to assess the sway of the body around the COP. The postural disorder is proportional to the amount of variations of these parameters from the symmetry values.

Figure 2.1 Stabilometric computerized platform, Postural Health Station (DL Medica SpA, Milano, Italy) demonstrating the position of feet during the measurement (Baldini, et al., 2013).

The detected data are transformed through the software with graphical interface that allow to present graphically posturometry and stabilometry results as well as to calculate the main characteristics of the posture.

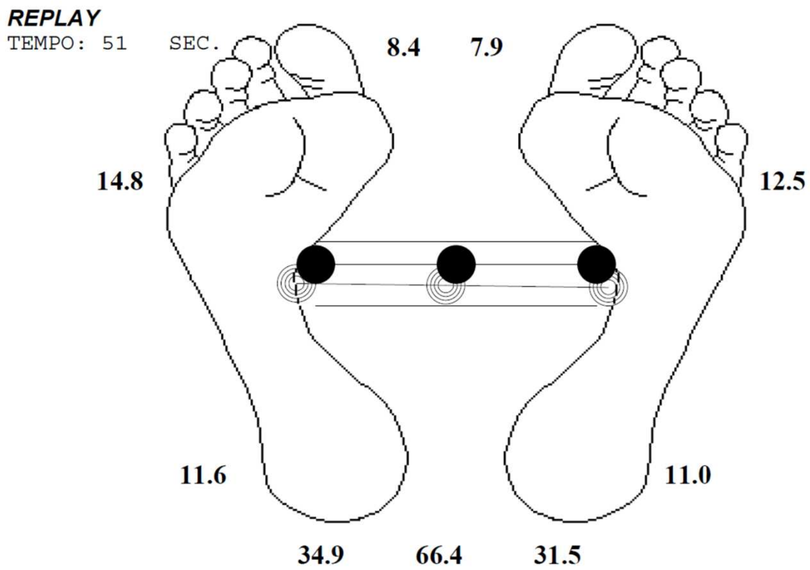

Figure 2.2 An example of posturometry results demonstrating the distribution of weight (in kg) on the various parts of the left and right feet, as well as position of the theoretical coronal plane (line going through the filled circles) and position of the patient’s coronal plane (circularly striped circles).

The main posturometry results are presented in the Figure 2.2. Looking at the card, one should imagine as looking on the patient from above. The data show the analysis of the general pressure and weight distribution (in kg) between the right and left foot and on the different parts of the foot: on the frontal part, side part, and on the back part or heel. The line going through the black filled circles represents the theoretical coronal plane. The line going through the circularly striped circles represents the patient’s coronal plane. In the ideal situation, the patient’s coronal plane should be close to the theoretical coronal plane and within the area represented with the two parallel lines (as in Figure 2.2). If the body of the person is tilted (falling) backwards or forwards, the patient’s coronal line will be placed more backwards or forwards, respectively. In Figure 2.3, the example is presented, where patient is tilted backwards. If the patient’s coronal line is oblique (see example in Figure 2.4), it demonstrates the rotation of the body around the vertical axis.

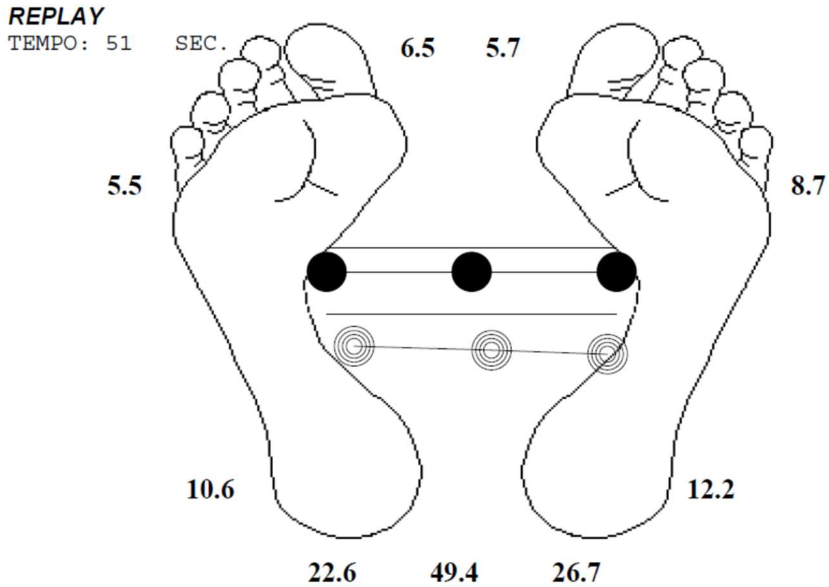

Figure 2.3 An example of posturometry results demonstrating the shift of patient's coronal plane (circularly striped circles) backwards.

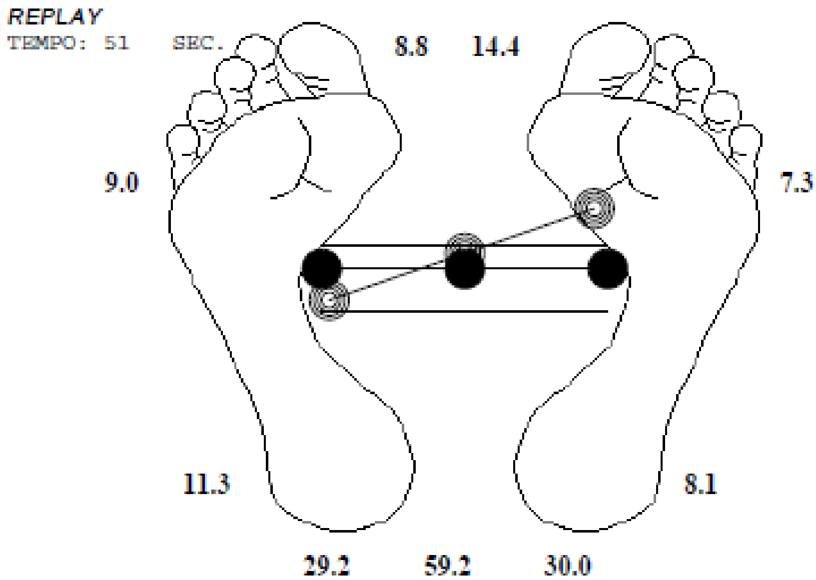

Figure 2.4 An example of posturometry results demonstrating the oblique position of the patient's coronal plane (circularly striped circles); the right part of the patient's body (mainly shoulder) is moved forwards and the left part of the patient's body (mainly shoulder) is moved backwards.

The main stabilometry results are presented in Figure 2.5. The test measures the stability of a patient through the precision of postural control and utilized energy both in medial-lateral (see Figure 2.5, upper graph) and anterior-posterior (see Figure 2.5, lower graph) directions. It helps to establish if a certain kind of posture is in the limits of normality or it contributes to the diagnosis of balance problems (peripheral or central vestibulopathy, cerebellar problems, cortical injuries, visual system problems, osteomuscular diseases). The graphics represent the possibility to fall. The more the body undergoes oscillations or sway closer to the axis (representing the calculated centre of the pressure of the patient), the less is the chance that a patient may fall. Greater oscillations or sway show a greater possibility of falling. This evaluation can be linked to the symptoms, for example, a patient having large sway amplitude can complain of having dizziness.

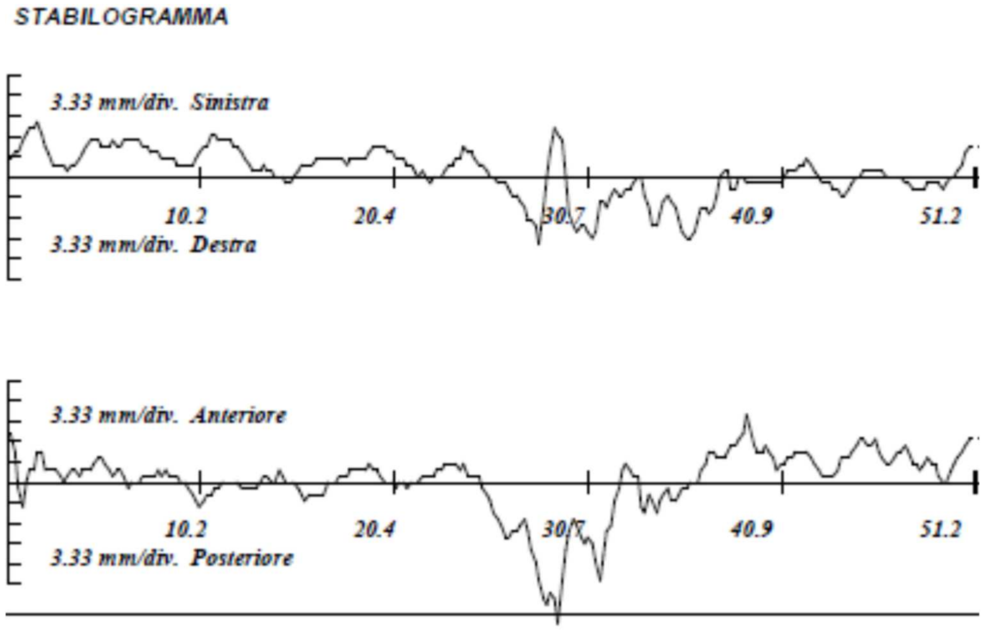

Figure 2.5 An example of stabilometry results demonstrating the large amplitude of oscillations or sway both in medial-lateral (upper graph) and anterior-posterior (lower graph) directions. The horizontal axis represents the calculated centre of the pressure of the patient.

The posturometry and stabilometry results are combined in statokinesiogram (see Figure 2.6) representing the centre of pressure (COP, see Figure 2.6, the crossing of the solid lines) and it's coordinates (Dist.x y) relative to the theoretical centre (see Figure 2.6, the crossing of the dashed lines), and calculated parameters characterizing the sway of the body around the COP: overall average velocity (Vel), average velocity in the anterior-posterior direction (A/P), average velocity in the medial-lateral direction (Lat), area (area) and length (lungh) of the COP sway. by means of the values that indicate how much the subjective projection deviates from the theoretical one. The area with the trajectory changes around the COP demonstrates so called "supporting ball" and is characterized with the area and length measurements. Also physiologically oscillations of the COP can be observed, because it is impossible to stay still for a long time. Therefore, the best balance and stability of the body is characterised with the smallest "supporting ball" (smallest sway both in medial-lateral and anterior-posterior directions) and the centre of pressure closer to the theoretical centre.

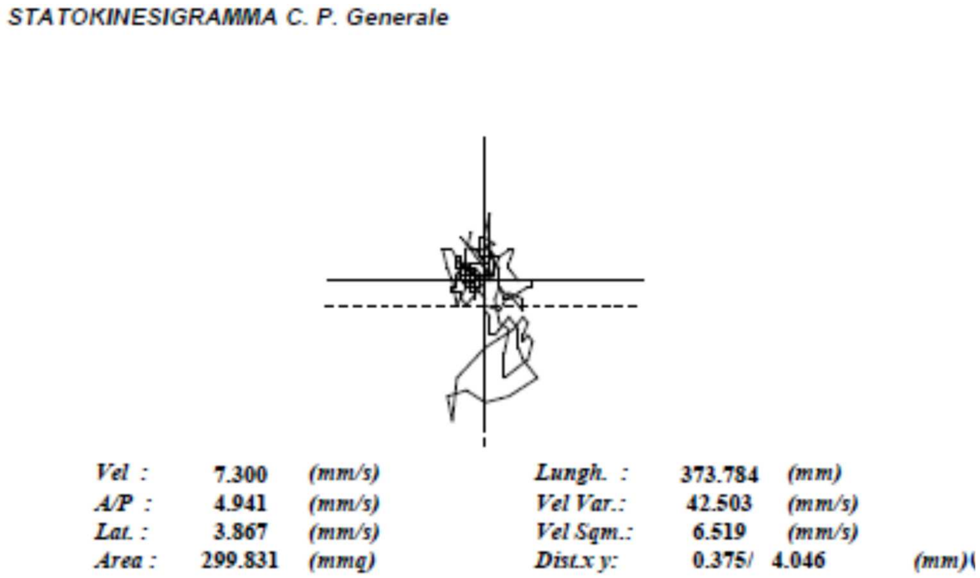

Figure 2.6 An example of statokinesiogram and calculated parameters of the COP sway.

All values represent a good feedback to analyse the effect of a sensorial afferent, in this case of the visual system, on the stability and position of the body. Following a wider conceptual route, one could even suppose in which regions the body struggles more in case of sway (oscillations) with a substantial difference between measurements taken before and after the optometric treatment. Since, for example, the abdominal and cervical muscles must manage these balances, if we think that these anomalous oscillatory movements are repeated all day long, we can easily imagine that the body can undergo big muscular and visceral stress.

2.2. Patient selection

No particular criterion was used for the selection of the patients who need treatment. The main criterions were symptoms (for example, headaches, cervicalgia, dizziness, pain in the shoulders, pain in legs or its parts such as lower limb, knees) and the postural problems observed in the stabilometric and posturometric examination such as differences of weight distribution between two feet, a rotation of the body, instability of the body during standing. Only patients were chosen for the research having no structural abnormalities such as a shorter arm, inflammations, meniscopathy etc. that could determine for example torsion of the hips and the shoulders. The selection was not performed according to age, sex, or race of the patient.

The age of the patients examined was between 26 and 56. Some had already optical correction, but some had a less stability with the correction in use as measured with the stabilometric computerized platform comparing condition with eyes opened (correction used) and with eyes closed. Six patients used bite during the nights because they had bruxism. In case of not using the bite, they experienced headache when awake. Two patients performed postural gymnastics. Most of the patients had prolonged near work, both for work and leisure. The visual acuity was almost always subjectively good (0.9 or better, decimal units) measured with correction in use for patients having refractive correction and without any correction in patients having no correction. In almost all patients, visual acuity differed by 0.10 - 0.15 (in decimal units) in two eyes with lack of respect for ocular dominance. Still, in posturology, it is important to evaluate even the smallest asymmetries. Because TPS (tonic postural system) work, and compensate just the small difference, while the big problem are manifest and uncompensated. In fact, it is the sum of compensation that creates the postural problem with a symptoms described in the previous paragraphs. This philosophy is valid for all measurements related to posture and physiology in general. Often, patients demonstrated micro saccades during the smooth pursuit, head rotation on the horizontal plane to support and centralize the dominant eye. There was also a reduction in physiological exophoria and increased break and recovery of the near point of convergence. It was frequently noticed that also centration of the lenses was not accurate.

2.3. Examination procedure

2.3.1. Optometric evaluation

Optometric evaluation was performed before the evaluation of the posture. The great emphasises was given to the case history to collect essential information and to understand the style of life and daily activities (work, sports), as well as nutrition to better classify the type of related disorders and correlate them with the visual functions. Apart from the traditional information, it is necessary to establish an emphatic relationship with the patient, who sometimes will approach the optometric visits with certain scepticism since he/she has already seen an eye specialist before and no one has ever reported any problems. Some of the patients examined had only just recently bought a pair of new glasses.

Each patient performed full optometric examination:

1) test of motor and sensory eye dominance,

2) visual acuity without and with correction in use,

3) phorias/tropia evaluation for near and far,

4) evaluation of eye muscle functions and eye movements,

5) evaluation of near point of convergence (break and recovery),

6) evaluation of binocularity (all three degrees of binocularity – simultaneous vision, fusion, and stereopsis),

7) ophthalmometry,

8) static and dynamic retinoscopy,

9) subjective refraction for far and near,

10) fusional reserves, at far and at near,

11) amplitude of accomodation,

12) positive and negative relative accomodation.

Part of the optometric examination was performed using phoropter. At the end of optometric examination, the measured data were evaluated and analysed in relation to the postural abnormalities and symptoms to find the most appropriate treatment option for each patient. Particular attention was paid to the mild anisometropia, as well as to the near point related data.

2.3.2. Posturometric and stabilometric measurements

After the full optometric examination, the posture was evaluated. All patients had measurements with eyes opened and eyes closed allowing to compare the effect of the visual information on the stability and balance. Duration of each recording is fixed (51.2 s). The measurements are carried out in a condition of silence without disturbing the patient with external stimuli such as excess of light and noise in the environment, the patient looks on the neutral fixation object not concentrating) positioned in front at about 3 meters distance. The patient was asked to stand as stable as possible, relaxed, with the arms kept free besides the body. These conditions must be reproducible, and then repeated every time the test is made. Before the test, the weight of the person must be inserted.

The test with the platform is carried out following a study protocol, besides, where necessary, considering each case individually, it is possible to carry out the test also by inhibiting the mouth receptor, inserting small cotton rollers in the mouth of the patient and therefore excluding the cusps of the teeth, that is the temporal mandibular articulation. This option is performed only if the symptoms referred and the gnathologic analysis justified it. In future, it could be also a part of a protocol. Other methods can be added besides the basic protocol considering the case history and the symptoms. This implies a discussion and data exchange with other professionals such as dentists, gnathologists, or osteopaths.

Thus, in some cases, for some patients, the measurement were made with the exclusion of the mouth receptor or with the use of a bite or insoles if already in use by patient to make the test conditions as true as possible and as close as possible to the everyday conditions of the patient. If the patient used any correction, the test was performed with the correction in use.

After optometric treatment (use of a new and improved correction, treatment with visual training, and behavioural and environmental treatment – the combination of all three treatment possibility depended on the needs of the patient), the posture evaluation was repeated following the same procedures, in the same room and under the same environmental conditions.

2.3.3. Optometric treatment

The part of the treatment included that all patients who needed or already had refractive correction got the new correction (glasses or contact lenses). All patients performed optometric visual exercises to restore normal oculomotoric functions, accommodation flexibility, and binocularity. At home, patients performed simple procedures, but, in office, more complex exercises were chosen depending on the subjective necessity of each patient. However, the aim of the visual treatment was the functional balance and reduction of symptoms in a shorter time period as possible and with the least possible frequency of visits. The aim of the treatment was also to make the treatment sustainable to avoid further stress resulting from the same training.

The following procedures was used:

- procedures to improve ocular motility and an awareness of the position of the eyes (Kraskin ocular stretching; rotator for pursuit, tables with letters);
- procedures to balance convergence\divergence system (bull's eye, jump vergence, Brook string);
- procedure to optimize visual-spatial functions, attention, eye hand coordination (space fixator);
- procedures to optimize the accommodation (flipper, Hart chart, exercises with phoropter in a dissociated vision).
- procedures to optimize fusional reserves (vectograms, anaglyphs, Life saver cards with transparent and opaque background).

If it was necessary, fixation stabilization was carried out using MIT (Macular Integrity Test). In some cases, visual training was combined with balance board and with yoked prisms. The yoked prisms were not used at home but just in office during training. The small prismatic values were considered that can be changed case by case based on the visual functions and case history.

While the behavioural and environmental aspects can modify the times and modes of work, the suggestions were given related to emotional approach to the work, the working distances, the environment in which the patient spends his/her time or reported having the major problems. For example, I suggested modifications of the room, a desk top or of its location, the placement of objects on the desk, the computer position with respect to the patient and its needs, of the chair, lighting (quality and quantity) .

2.5. Results and analysis

2.5.1. Data analyses

For the statistical evaluation, examination results were compared before and after the treatment using t-test (paired two samples for means) with $p < 0.05$ (one-tailed). Each test was performed both with closed eyes and with opened eyes in order to comply with the standard procedures of stabilometric and posturometric examinations.

The data examined were:

1) the weight distribution in anterior-posterior (the distribution of weight between the forefoot and heel on both left and right sides) and medial-lateral (in between two feet) directions,

2) the position of the centre of pressure (COP) relative to the theoretical centre,

3) area and length of the shape of the COP sway (oscillations), its velocity.

2.5.2. The weight distribution

The weight distribution was calculated both for:

- anterior-posterior direction (weight ratio, $wi_{a/p}$):

$$wi_{a/p} = (L_f + R_f)/(L_b + R_b),$$

where L_f – registered weight on the front part of the left foot, R_f – registered weight on the front part of the right foot, L_b – registered weight on the back part (heel) of the left foot, R_b – registered weight on the back part (heel) of the right foot (see Figure 2.7);

- medial-lateral directions (weight ratio, $wi_{m/l}$):

$$wi_{m/l} = L_w/R_w,$$

where L_w – registered weight on the whole left foot, R_w – registered weight on the whole right foot (see Figure 2.7).

n the ideal balanced situation, both weight ratios should tend towards 1. If weight ratio is larger (smaller) than 1 in anterior-posterior direction, the patient tends to tilt forwards (backwards). If weight ratio is larger (smaller) than 1 in medial-lateral direction, the patient tends to tilt to the left side (right side).

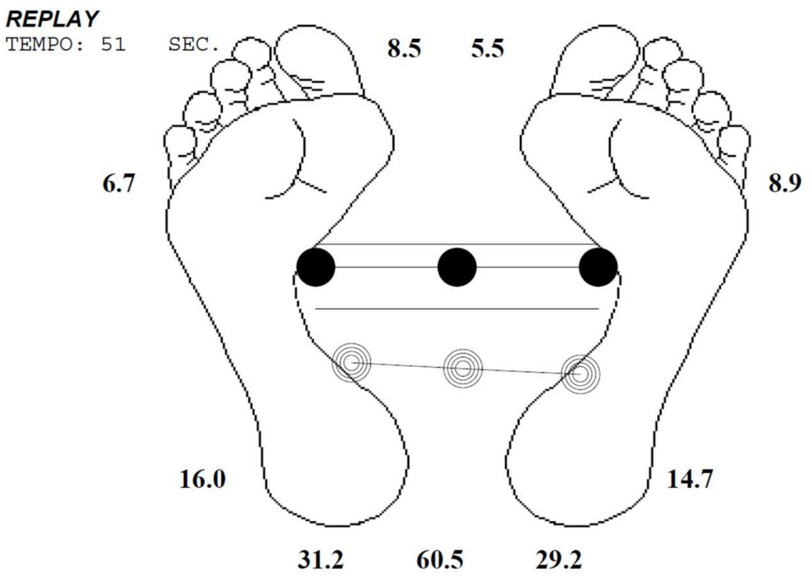

Figure 2.7 Posturometry presenting the weight distribution (in kg) for the right and left feet as well as an overall weight of the patient (in the middle – 60.5 kg) before the treatment with the eyes opened. L_f – registered weight on the front part of the left foot, R_f – registered weight on the front part of the right foot, L_b – registered weight on the back part (heel) of the left foot, R_b – registered weight on the back part (heel) of the right foot, L_w – registered weight on the whole left foot, R_w – registered weight on the whole right foot. The weight ratio in anterior-posterior direction is 0.46

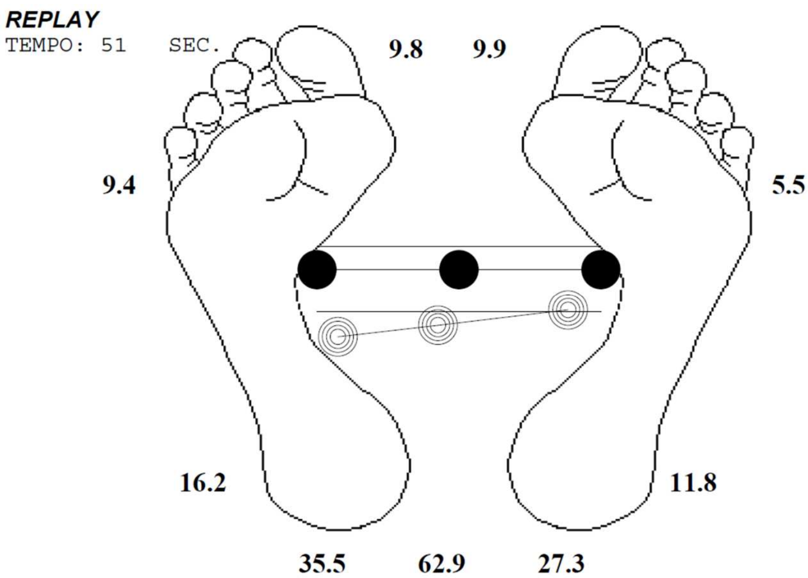

Figure 2.8 Posturometry for the same patient as in Figure 2.5 presenting the weight distribution (in kg) for the right and left feet as well as an overall weight of the patient (in the middle – 62.9 kg) after the treatment with the eyes opened. The weight ratio in anterior-posterior direction is 0.70

Analysed data demonstrated that the weight ratio in anterior-posterior direction increased in most of the patients (see Figure 2.9) and tended to value 1 if the eyes were opened. The observed improvement was statistically significant (t-test, one-tailed: $p = 0,0097$). If the eyes were closed (see Figure 2.9), the weight ratio had small and not statistically significant improvement after treatment (t-test, one-tailed: $p > 0.05$). Only two patients (out of eleven) demonstrated large changes to equalize the weight in anterior-posterior direction both with opened and closed eyes.

Weight ratio in medial-lateral direction (see Figure 2.10) showed no statistically significant difference both in open and closed eye situation (t-test, one-tailed: $p > 0.05$). However, most of the patients (9 out of 11) had smaller variation of the weight ratio after the treatment compared to before treatment measurements if the eyes were opened.

Data analyses demonstrate that the treatment improved anterior-posterior weight distribution, minimizing the possibility for patients to fall backwards (see example in Figure 2.7 and Figure 2.8).

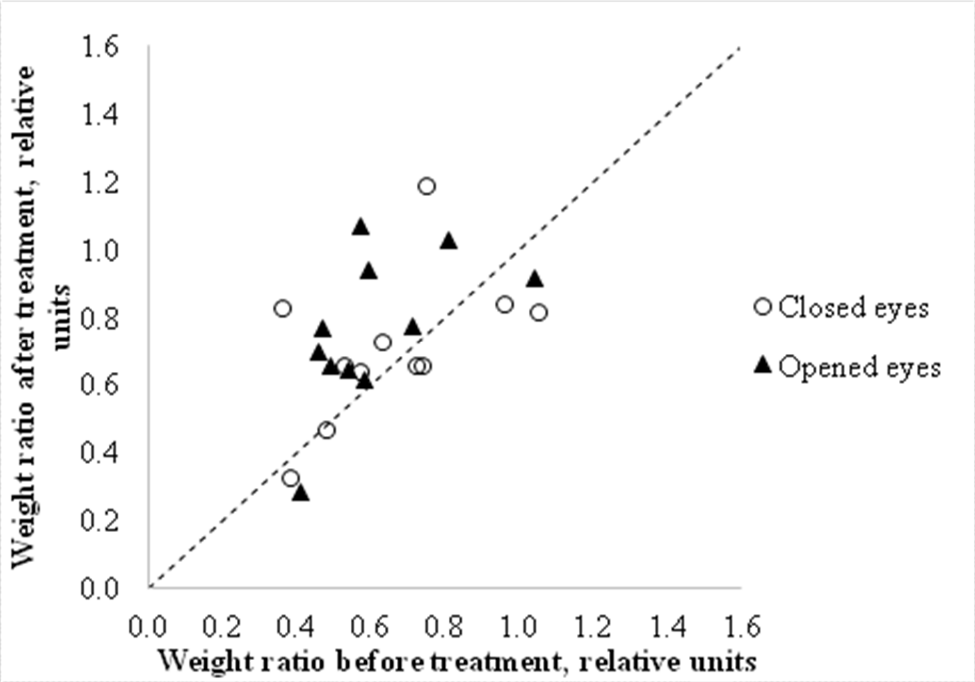

Figure 2.9 The weight ratio in anterior-posterior direction before and after treatment. The dashed line represents the ideal line if there would be no changes after the treatment.

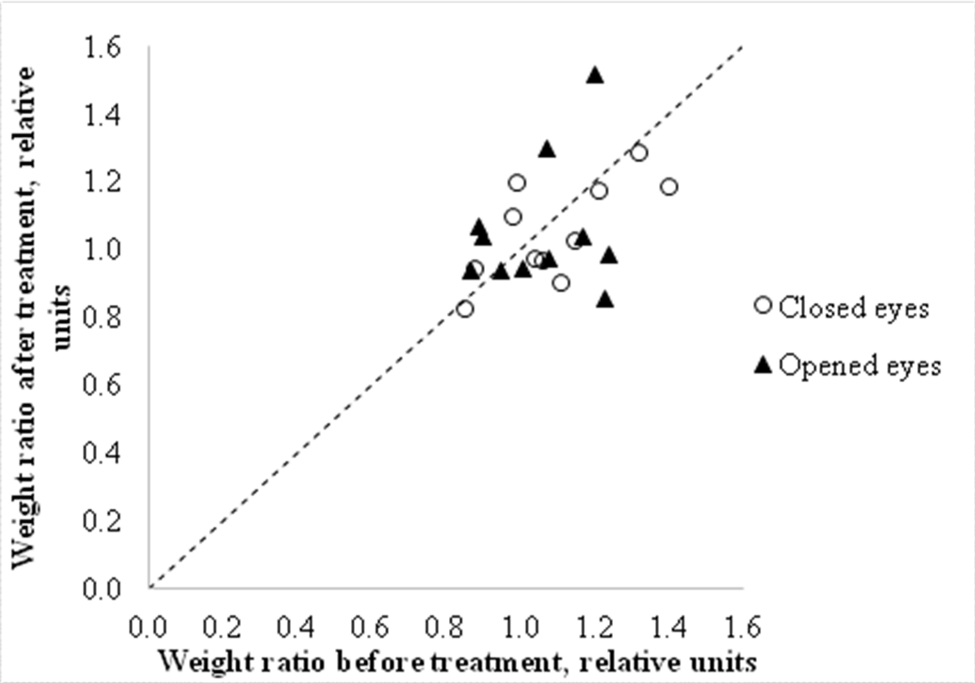

Figure 2.10 The weight ratio in medial-lateral direction before and after treatment. The dashed line represents the ideal line if there would be no changes after the treatment.

2.5.3. The position of centre of pressure (COP)

After the treatment, it was expected that the COP would be closer to theoretical centre of the stabilometric platform. For this analysis, the vector was calculated representing the distance and direction of COP relative to the theoretical centre. Only length of the vector was analysed, taking the coordinates x and y of the COP:

$$V_{COP} = \sqrt{x^2 + y^2}$$

For example, Figure 2.11 and Figure 2.12 demonstrate the COP position for one patient before and after treatment. It can be seen that vector is shorter after the treatment despite that it is shifted to the left side compared to the situation before the treatment. This is the same patient as in Figures 2.7 and 2.8. Thus, all data together show that the patient demonstrates posture that is more stable and closer to centre after treatment.

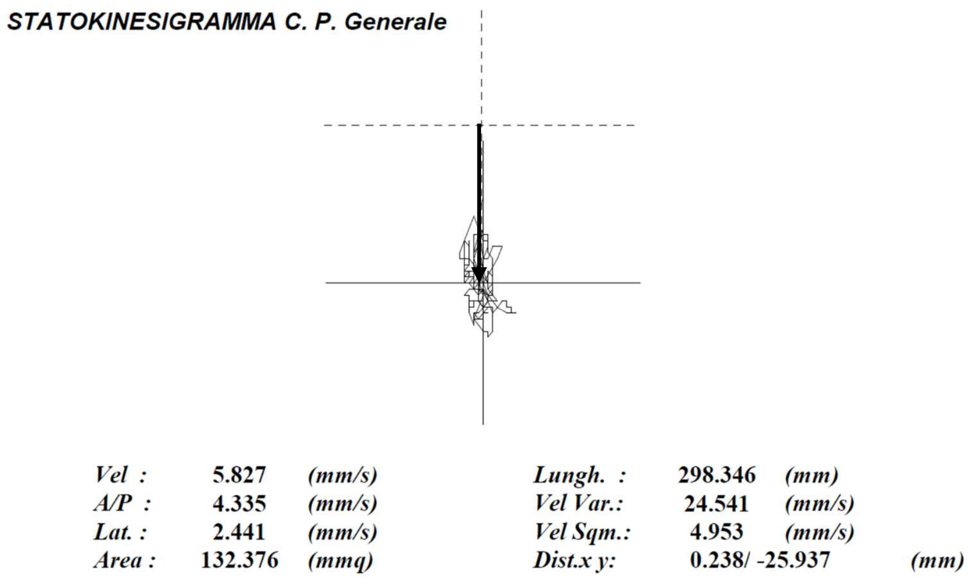

Figure 2.11 Statokinesiogram before the treatment with the eyes opened. The crossing of the dashed lines presents the theoretical centre (defined by the platform) and the crossing of the solid lines presents the position of COP. The coordinates of COP (relative to the theoretical centre) are shown as dist.x y. The arrow is the vector representing the distance and direction of COP relative to the theoretical centre.

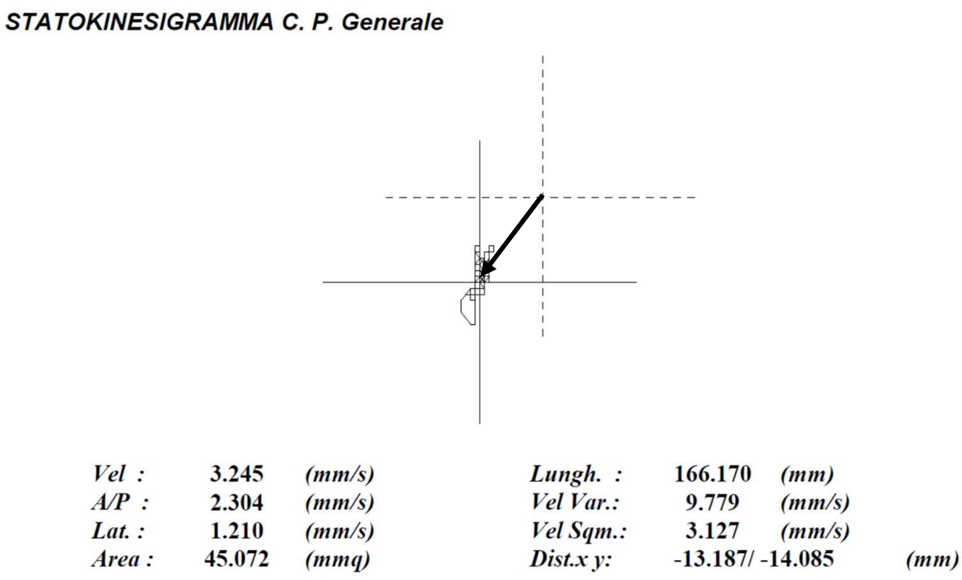

Figure 2.12 Statokinesiogram after the treatment with the eyes opened for the same patient as in Figure 2.9. The crossing of the dashed lines presents the theoretical centre (defined by the platform) and the crossing of the solid lines presents the position of COP. The coordinates of COP (relative to the theoretical centre) are shown as dist.x y. The arrow is the vector representing the distance and direction of COP relative to the theoretical centre.

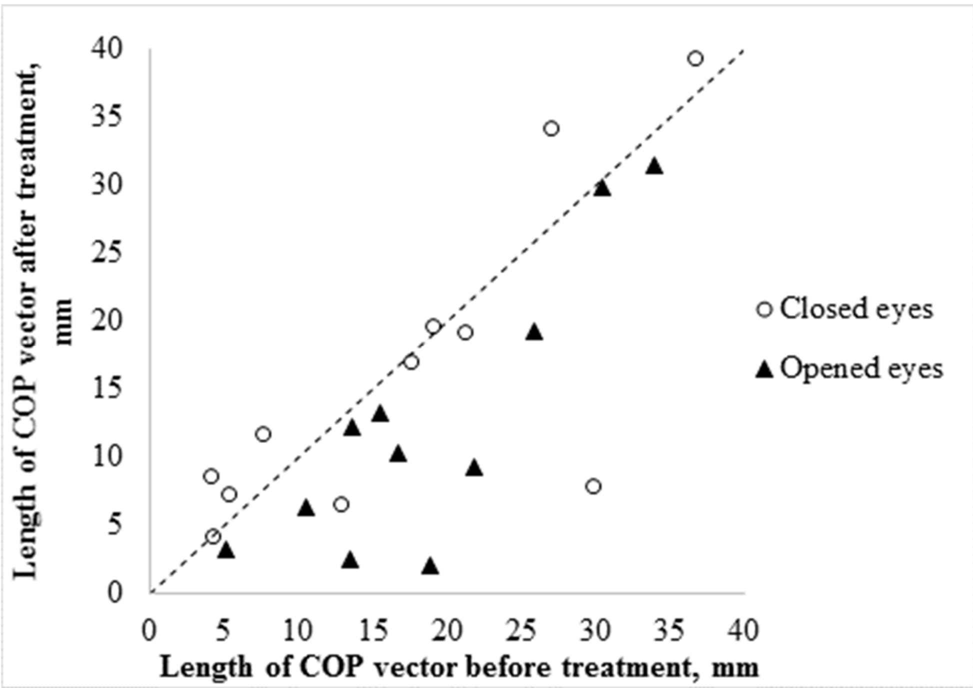

Figure 2.13 The COP vector before and after treatment characterizing the distance from the theoretical centre and the centre of the pressure.

The data in the whole group of patients (see Figure 2.13) show that COP vector is statistically significantly smaller after treatment in all patients if the eyes are opened (t-test, one-tailed: p = 0.002). If the eyes were closed, only two patients showed shorter COP vector. But in all group, there are no statistically significant improvement after treatment if the eyes are closed (t-test, one-tailed: p > 0.05).

Data analyses demonstrate that the treatment improved the position of the centre of pressure relative to the theoretical centre and consequently improved the stability of patients in situation when the eyes are opened.

2.5.4. Velocity, area and length of the shape of the COP sway

COP do not have a stable position. COP is characterized with its sway parameters: velocity, area, and length. The goal of the treatment is to have smaller velocity, sway area and length that would lead to more stable posture and less possibility to fall. Figure 2.14 and Figure 2.15 present the example of the stabilogram for one patient (the same as in Figure 2.7, Figure 2.8, Figure 2.11, and Figure 2.12) before and after treatment if measurements were performed with eyes opened. The data show that patient had remarkably smaller sway in medial-lateral direction and decreased sway in anterior-posterior direction after treatment.

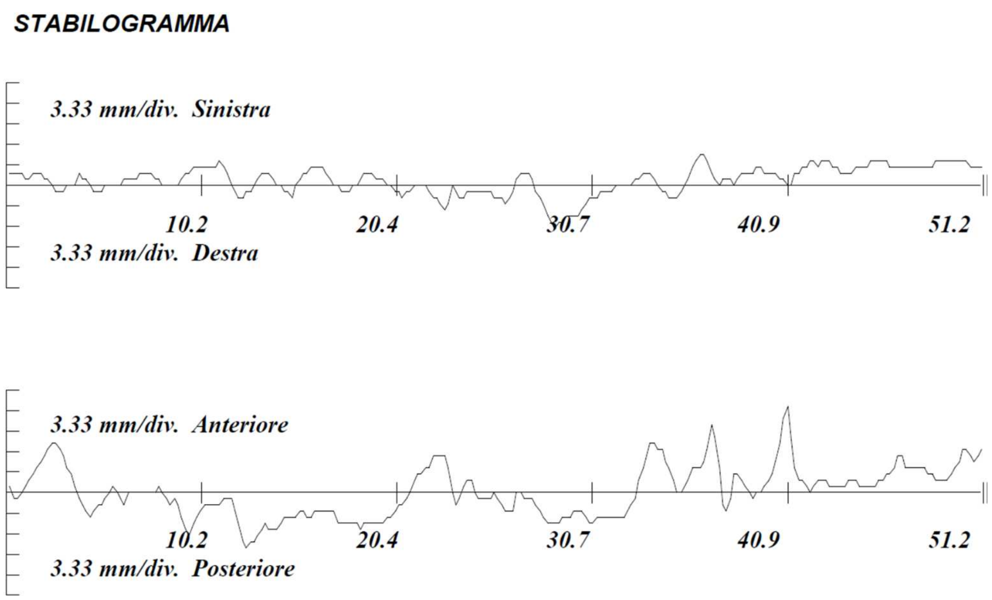

Figure 2.14 Stabilogram before the treatment with the eyes opened: the changes of the position of COP around the calculated average of COP in medial-lateral position (upper graph) and in anterior-posterior position (lower graph). Overall duration of the measurement was 51.2 s.

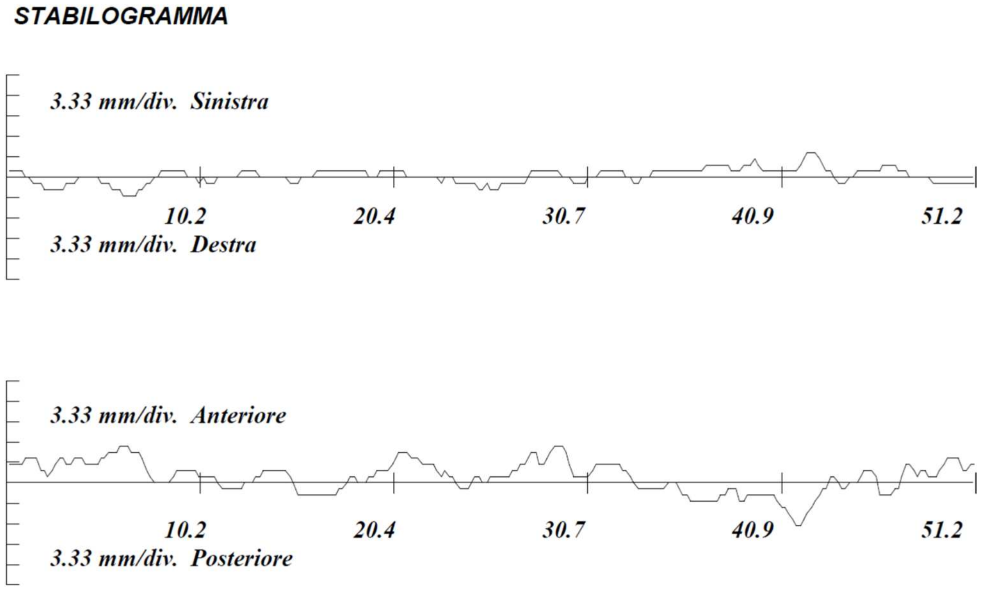

Figure 2.15 Stabilogram after the treatment with the eyes opened for the same patient as in Figure 2.12: the changes of the position of COP around the calculated average of COP in medial-lateral position (upper graph) and in anterior-posterior position (lower graph). Overall duration of the measurement was 51.2 s.

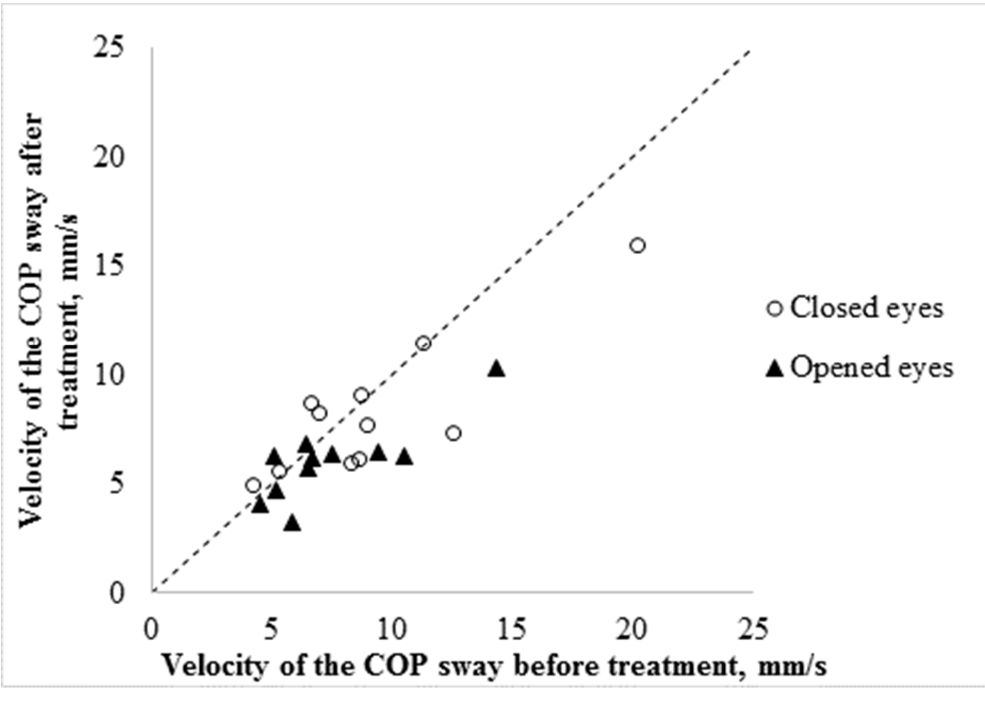

Figure 2.16 The velocity of the COP sway before and after treatment.

The values of velocity, area, and length were smaller after treatment (see Figure 2.11 and Figure 2.12: Vel, Area, Length). It can be seen also from so called “supporting ball” (see Figure 2.11 and Figure 2.12: area drown around crossing of solid lines); after treatment, it is more compact.

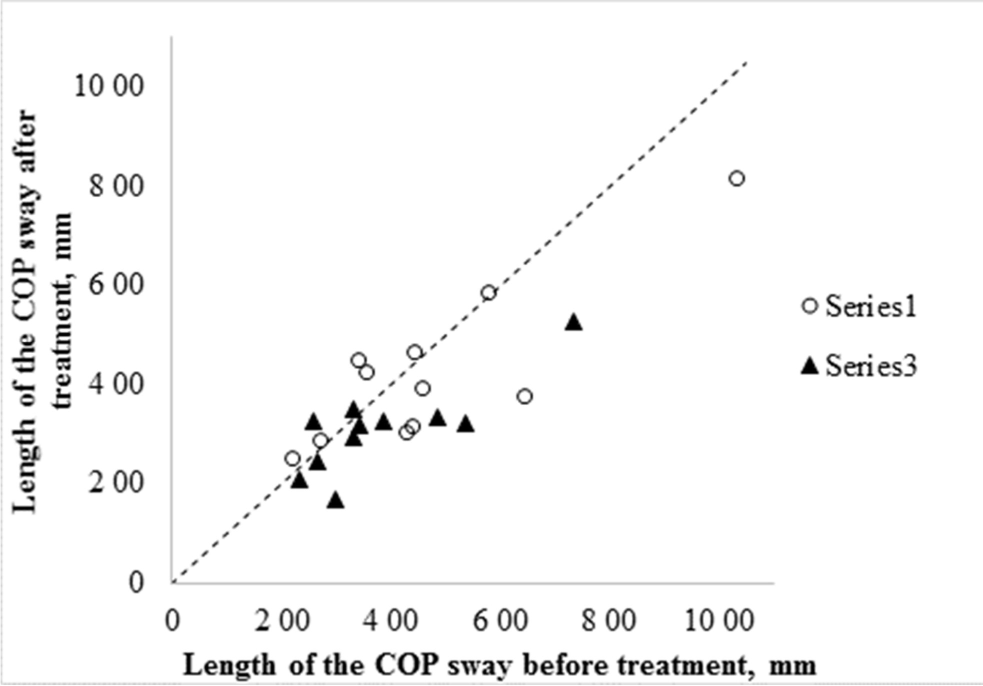

Figure 2.17 The length of the COP sway before and after treatment.

Analysing the results for all patients, velocity of the COP sway (see Figure 2.16) was statistically significantly smaller after the treatment only in measurements with eyes opened (t-test, one-tailed: $p = 0.01$) and not with eyes closed (t-test, one-tailed: $p > 0.05$). Similar results were observed also for the length and area of the COP sway. The length of the COP sway (see Figure 2.17) was significantly smaller after treatment in measurements with eyes opened (t-test, one-tailed: $p = 0.01$) and not with eyes closed (t-test, one-tailed: $p > 0.05$). The area of the COP sway (se Figure 2.18) became significantly smaller after treatment in measurements with the eyes opened (t-test, one-tailed: $p = 0.006$). When the eyes were closed, statistical analyses showed there was significant decrease in the area (t-test, one-tailed: $p = 0.046$). However, the data demonstrated that the large decrease was observed only in two patients.

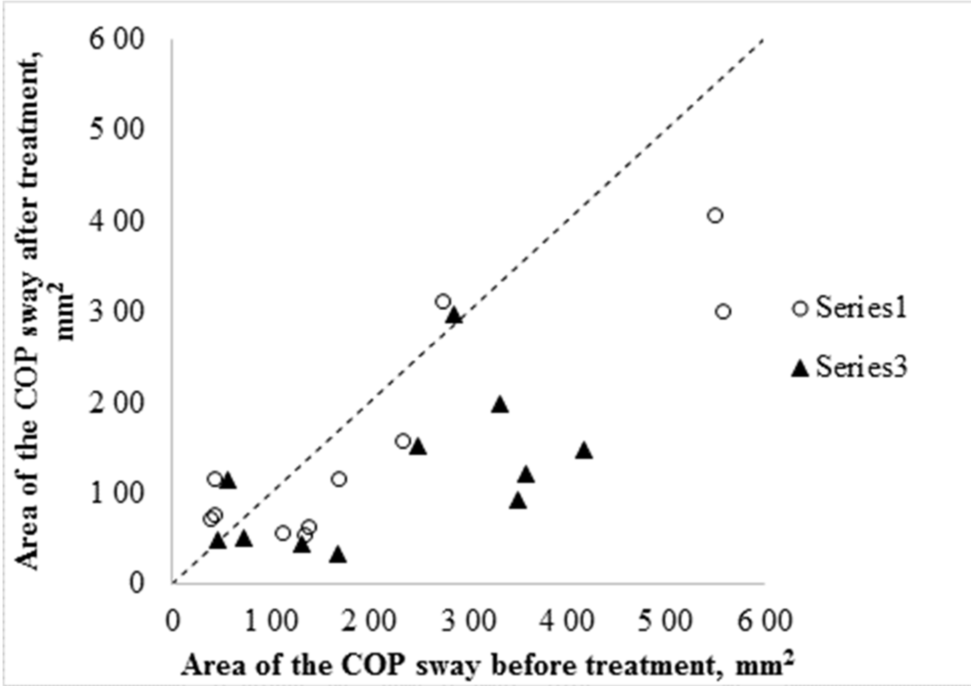

Figure 2.18 The area of the COP sway before and after treatment.

Overall changes in the COP sway also confirmed the significant improvement of stability of the patients after the treatment if the measurements were taken with the eyes opened.

2.6. Discussion

The results demonstrate that the visual information is not neutral in a postural context, but instead it represents a very important source of postural information. If the eyes are opened, a more functional, more reactive condition is achieved because it is rebalanced with optometric treatment and also because it is normally used, schematized. If the postural system does not have an important information such as the visual one like in condition with closed eyes, it must adopt postural patterns relaying on the other sensorial information, for example the foot or vestibular way. However, it cannot be performed without using part of the visual information inserted in the motor pattern, that is excluding the eyes, but not the vision that by its nature uses the visualization in absence of sight. Therefore, the last scene before closing the eyes is visualized and the muscles continue normally to send signals to the muscular proprioceptors participating in the connective muscular chain.

There were patients with better stability before treatment in condition with the eyes closed than opened. This can happen due to evident visual problems that created continuous postural adjustments. Excluding them, the system normalizes. Other reason could be that the visual system becomes more alarmed and stiff with no direct visual stimulation. Therefore, it seems more centred.

Posture is a result of multi sensorial interaction. One must try to do the posturometric test differentiating as far as possible the sensorial receptors in order to understand if one of them could be a cause of postural and balance problems. Therefore, not only closed eye position allows to exclude visual information, but also inserting of some small cotton rolls in the mouth of the patients allows to exclude dental contacts.

Some studies demonstrate that it is possible to obtain best research and results in multidisciplinary way. However, there is limited number of studies were vision specialists are involved.

Monaco, et al. (2004) conducted the study to assess the occurrence of ocular convergence defects between patients with functional mandibular latero-deviation (see an example in Figure 2.19 and Figure 2.20) and healthy patients in paediatric age. Sixty patients (the study group) presented mandibular latero-deviation classified as functional according to the use of a clinical examination and frontal and basal tele-radiography. Sixty patients without functional mandibular laterodeviation (control group) were selected randomly from all patients seeking paediatric dental care. All patients in the control group were matched by gender and age with the study group. All patients had orthoptic tests performed by the same specialist. The results confirmed that patients with in mandibular latero-deviation had ocular convergence defects more often than controls.

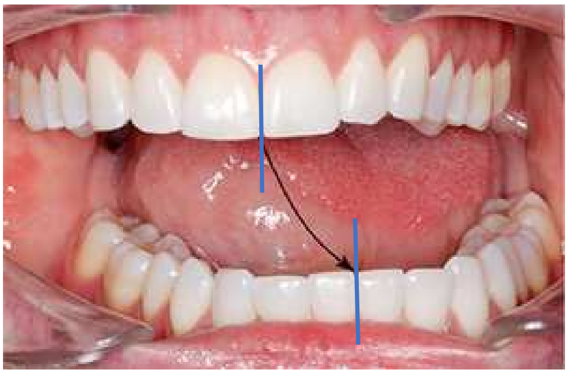

Figure 2.19 A misalignment of mandibula in open mouth, the occlusal midlines are in blue lines (www.treatingtmj.com).

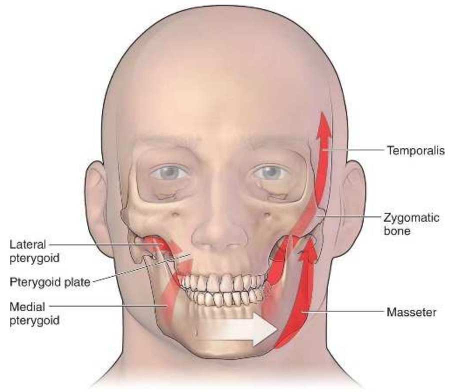

Figure 2.20 Anatomic scheme of mandibular misalignment (https://musculoskeletalkey.com)

Friedrich, et al. (2008) studied the influence of simulated visual dysfunctions on posture. In the first part, visually handicapped patients and patients with normal vision were investigated with posturometric method to evaluate postural stability in opened and closed eyes conditions. Significant differences of the postural stability between both groups were found only in the test position with opened eyes. The healthy group showed a significant loss of stability, whereas the impaired group showed an increased stability due to sufficient somatosensory processes. Visually handicapped patients can compensate the visual information deficit through improved peripheral-vestibular and somatosensory perception and cerebellar processing.

In the second part, patients with normal vision were examined under simulated visual conditions, e.g., hyperopia (+3.00 D), reduced visual acuity (20/200 or 0.1 in decimal units), yoke prisms (4 pd) and pursuits (pendulum). Changes in postural parameters due to simulations have been compared to a standard situation (opened eyes, fixation distance 3 m). A loss of stability was measured for simulated hyperopia, pendulum, and yoke prisms base down. Stability regulation can be understood as a multi-sensory process by the visual, vestibular, somatosensory and cerebellar system. Reduced influence of a single subsystem is compensated by the other subsystems. Obviously, the main part of reduced visual input is compensated by the vestibular system. Moreover, the body sway, represented by the stability indicator, increased in this situation.

Monaco, et al. (2013) reported a case report of a 14-year-old Caucasian girl affected by strabismus and referred for the treatment of a class III malocclusion with transverse maxillary deficiency, which was corrected with the application of a rapid maxillary expander (Haas type) (see an example in Figure 2.21).

Figure 2.21 Example of rapid maxillary expander (http://www.jios.in).

One week before the application of the Haas-type device, the patient underwent an ophthalmologic and orthoptic examination, which showed a normal visual acuity, hyperopic astigmatismus in the right eye, mixed astigmatismus in the left eye, and a normal fundus oculi. The cover test showed an intermittent exotropia with a "V" pattern deviation, where the angle of deviation became smaller going from upper to lower gaze position. The evaluation of the extraocular muscles (MOE) revealed the presence of a hyperfunction of lateral rectus and inferior oblique muscles in both eyes, as well as a convergence defect, with a near point of convergence (NPC) at 8 cm. Based on those clinical outcomes, the ophthalmologist prescribed corrective glasses that the patient refused to wear. Two months after palatal expansion, the patient came back to the ophthalmologist, who assessed a remarkable change in her oculomotor defect. Intermittent exotropia turned into a simple exophoria, since the clinical evidence of the ocular disorder disappeared, the angle of deviation slightly decreased, and NPC improved. The MOE evaluation showed a normal muscular function, Lang II stereotest and Worth 4-dot test revealed a good binocular cooperation. During the entire period of the orthodontic treatment, she had no other medical treatment and did not report the consumption of any drugs. Thus, the results demonstrated the remarkable modification of the oculomotor system by treating gnatological problems.

Robey & Boyle (2013) described the patient with Sacroiliac joint dysfunction (SIJD) and a visual midline shift syndrome. There was a multidisciplinary management between an athletic trainer and an optometrist. A 21-year-old collegiate baseball player reported to the athletic training room, presenting with low back pain of three-day duration, with tenderness over both posterior superior iliac spines (PSIS) (left > right). His pain at its worse was a 7/10 on the Numeric Pain Scale (NPS) (see an example in Figure 2.22). The pain increased to the point that limited his activities of daily living.

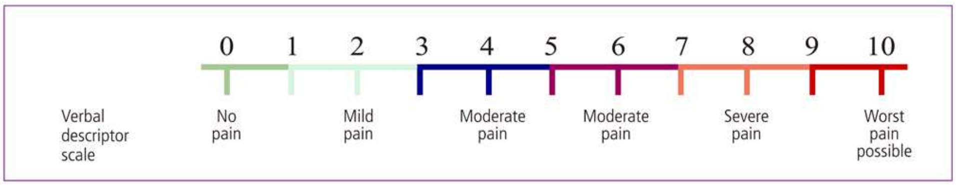

Figure 2.22 An example of Numeric Pain Scale (www.ogscience.org).

The athlete was initially treated using traditional muscle energy techniques based intervention to correct SIJD, and lumbar stabilization exercises directed by a licensed athletic trainer, as well as manipulation by a chiropractor. Three weeks of treatment did not prove to be beneficial with only a minimal (1 point on the NPS) decrease in pain. The athlete was then referred to the head athletic trainer for consultation who prescribed orthotics, for bilateral rear-foot valgus, and postural restoration therapeutic exercises. After two weeks of orthotic use and postural restoration exercises, the athlete's pain decreased one additional point on the NPS. Due to lack of progress, an optometrist was then consulted. The neuro-optometrist prescribed 2 pd base-down prisms to be worn two hours a day, for four weeks. After four weeks of prisms and new exercises, the athlete was asymptomatic and returned to full pain-free baseball participation without further complications. The athlete demonstrated only minimal relief of symptoms following muscle energy techniques, therapeutic exercises, and chiropractic manipulation. Intervention using prism glasses and postural restoration exercises, designed to optimize posture and correct his visual midline shift syndrome, led to complete resolution of his symptoms.

All these results demonstrate that treatment of patients should be a teamwork involving various types of specialists. In addition, the results of Master thesis clearly demonstrate the influence of vision on the posture. This naturally leads to collaboration with other professionals and to the development of shared work protocols.

CONCLUSIONS

1. The weight distribution in anterior-posterior direction was significantly more balanced after the optometric treatment with the eyes opened. The weight distribution in medial-lateral direction had no effect of the optometric treatment.
2. When the eyes were opened, the centre of pressure moved closer to the theoretical centre and its speed sway, length and area became smaller. This means that the body tended to be more centred thanks to the improved visual information.
3. After optometric treatment, the most statistically significant changes in the results of the postural and stability parameters were observed with the eyes opened. When the eyes were closed, no statistically significant changes were observed. Thus, improvement of visual quality can directly affect the posture and balance of the patient.

FINAL WORDS

The results of the study demonstrate the effect of optometric intervention on the postural changes. The stability of the patients improved after visual treatment. Thus, optometrists can not only improve people's sight, but also improve their quality of life.

The instrumentation used has a high reproducibility and allows to follow the patient in his/her changes and improvements step by step. The data obtained is easily shared with other professionals. Therefore, the use of stabilometric and posturometric measurements can be easily used also by the optometrists.

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Supervisor: docent, Dr.phys. Aiga Svede

Reviewer: docent, Dr.phys. Sergejs Fomins

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Dean's authorized person: _________________________

Thesis is defended in State examination commission session

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