BJCR Brazilian Journal of Case Reports

PCAA Publicações Científicas de Acesso Aberto

Experimental Reports

Prevalence of cervical postural alterations in oculomotor disturbances: a Brazilian cohort study

Júlio César Claudino dos Santos [1,2,*], Luciano Barroso de Albuquerque Filho [2], Emille Magalhães Neves Campos [3], Maria Angela Silva Dias de Araújo [4], Maria Goretti Fernandes [4], Marcos André dos Santos [4], Maria Amélia Silva de Sousa Ribeiro [5], Rafaella Iughetti da Costa [2], José Amarilo Sampaio Junior [2], Maria Victoria Rocha Fontenele Maia [2], Jullie Albuquerque [2], Pedro Henrique Cardoso [2], Bruna Reis [6], Silvana Dezan Brito [6], Luiz Aldir da Silva [6], Leandro Freitas Oliveira [7]

[1] Universidade Federal do Ceará, UFC, Fortaleza, Ceará, Brazil.
[2] Centro Universitário Christus, Unichristus, Fortaleza, Ceará, Brazil.
[3] Faculdade de Medicina, Universidade Federal de Roraima, Boa Vista, Roraima, Brazil.
[4] Universidade Católica de Pernambuco, Departamento de Fisioterapia, Recife, Pernambuco, Brazil.
[5] Hospital dos Olhos Santa Luzia, Recife, Pernambuco, Brazil.
[6] Christian Business School, CBU, Orlando, Florida, EUA.
[7] Universidade Católica de Brasília, UCB, Brasília, DF, Brazil.

* Correspondence: julio.santos@alu.ufc.br.

Citation: dos Santos JCC, Albuquerque-Filho LB, Campos EMN, de Araújo MASD, Fernandes MG, dos Santos MA, Ribeiro MASS, da Costa RI, Sampaio-Junior JÁ, Maia MVRF, Albuquerque J, Cardoso PH, Reis B, Brito SD, da Silva LA, Oliveira LF. Prevalence of cervical postural alterations in oculomotor disturbances: a Brazilian cohort study. Brazilian Journal of Case Reports. 2023 Oct-Dec;03(4):6-17.

Received: 19 April 2023
Accepted: 9 May 2023
Published: 10 May 2023

Abstract: The literature suggests that maintaining correct posture depends on a balance between orientation and balance, which is linked to the reflex relationship between the oculomotor system and the superior cervical spine. Any disruption to this relationship can cause postural deviation, as the posture is dependent on head balance and eye horizontality. This study aimed to investigate the prevalence of cervical posture alterations, such as head tilt, rotation, and protrusion, scapular waist changes, scoliosis, kyphosis, and lumbar hyperlordosis, in patients with oculomotor disturbances, including convergent, divergent, and vertical squint, and convergence insufficiency. The study evaluated 24 patients aged between 4 and 39 years old, both male and female, through ocular motility and postural examination. The results showed that all patients with oculomotor disturbances also had postural imbalances, and the percentage of alterations in the posture segments was high. Therefore, oculomotor disturbances can cause postural imbalance, leading to orthopedic and facial asymmetry. The study concluded that patients with oculomotor disturbances should be evaluated to determine the compensatory positions they adopt and set a better visual performance that does not alter their appearance in the long term.

Keywords: Posture; Balance; Oculomotricity; Squint; Stiff neck.

1. Introduction

An individual´s posture is influenced by the skull´s positioning and the head movement, which are connected to the cervical spine region [1,2]. The neck sustains the head over the body and articulates in its spatial orientation movements, related to gravity and also to sensorial localization of surrounding stimuli [3]. The postural act is a complex task which involves an intricate relationship between sensorial information and motor activity. The balance between the supporting structures' minimal effort and a maximum body efficiency indicates the ideal posture [4,5]. The posture control has the purpose of orienting and balancing the body for the activities' satisfactory performance, utilizing the sensorial systems involved in the balance: vestibular, somatosensory, and visual, with the main source of information being visual in the beginning of the child's motor development a [6,7]. The postural balance is the relative balance of the internal and external forces, which acts on the body during motor actions, and, at the same time, the execution of these motor actions influences the obtainment of sensory information [8]. Based on this information, the postural control identifies the operation of the associated body segments and their strength to control the adequate and appropriate muscular activity for this activity, maintaining the balance [9,10]. The posture is individual and determined by muscular chains, fasciae, ligaments, and bone structures that have an interruption, which are independent in each other and are present in the whole body [11].

The correct characteristic of a postural deviation is not well determined yet, because the man still finds himself in evolution of its biped posture and this fact excludes the possibility of defining a standard posture. The human posture is unstable and varies according to the psychosocial cultural and biological conditions, being the postural deviation an important cause of morbidity in the population. The preservation of these factors in an indicator of healthy posture [12]. Amongst the disorders of the musculoskeletal system, the vertebral pain presents itself as a modern society problem. In the deficient posture, there is an abnormal relation between various body parts, resulting in excessive solicitation of the supporting elements and in the decrease of the perfect balance of the body over its supporting foundation.

The excessive relation of the supporting elements which involve the posture can lead to a misbalance, which can cause an abnormal proportion and the imperfection of the foundation that supports the body, causing chronic trauma over the articulations and the associate structures, exacerbating pathogenesis and pain in the vertebral spine [13,14]. Since the beginning of the last century, Charles Bell used to ask, "*how can the man maintain posture when standing or inclined against the wind?*". In that period, it was already speculated that the main sensory receptors would be responsible for the man´s erect position, evidencing the importance of the eyes, the paravertebral muscles' proprioception, and the vestibular system [15,16].

The look is included in the visual system alongside the neurological structures of the visual pathway and the ocular muscles. The human mechanism of adjusting the balance and the posture involve a reflex relation between the oculomotor system and the superior cervical, which results from the information coming from the vestibular and ocular systems, associated with proprioceptive information which originate in the cervical spine. The superior cervical spine´s muscles maintain the balance of the head and the horizontality of the look [17, 18].

The Central Nervous System (cortical and subcortical) organizes the demands of the oculomotor nerve (binocular positional adjustments) in a complex way, with the action of six external muscles from each eye, producing the rotations. All of this depends on the reception and interaction of visual stimuli [19, 20].

Amongst the cervical postural problems there is the torticollis, a condition in which the head stays mispositioned in relation to the torso, which has the etymological meaning of "crooked neck" [21, 22]. This alteration is defined as a contractual state of the cervical musculature, reflecting on the neck and causing an altered head position, which can be caused by an ocular condition, also known as a vicious head position, and non-ocular (musculoskeletal) [23]. The torticollis describes the condition of a cephalic deviation in relation to the torso, which can occur from orthopedic causes (cervical alterations or muscular contracture), ocular cause (oculomotor imbalance, squint) and neurological (supranuclear paralysis of the conjugated movements and nystagmus) [24]. The differential diagnosis between the orthopedic and the ocular causes is done via specific tests.

The congenital or infantile torticollis has orthopedic causes and is characterized by the lateralization of the head associated with body rotation [25]. When of anatomical origin, it is justified by the joint defects of the cervical spine´s vertebrae [26]. In this alteration, the head cannot be repositioned passively with the hands, while in torticollis (vicious head position) originated from an ocular cause the correction of the inclination passively is possible.

The vicious head position is a compensatory position which aims to provide better visual efficiency and a binocular vision to the patient, insinuating that the problem isn´t (primarily) on the neck, but it's in the head (seeing, listening), which position is vicious (defective) and not casual [27]. It compromises the aesthetic long term and can cause orthopedic disorders and facial asymmetry [28]. In the first years of life, during the child's development, the vision plays a predominant role as motivator of communication and making motor action happen. The vision is the relationship with the exterior world and any ocular problem can represent severe loss in socialization and in learning [29, 30].

In the superior primates (and in men), the visual perception of space has its foundation in the frontalization of both eyes, done simultaneously and, obviously, beyond sensory capacity, it is also necessary to balance the oculomotor, which muscular movements can´t be restricted [31, 32]. The eye is at the same time an internal and external receptor of the tonic postural system [33]. The gaze results from cephalic and ocular movements and has the aim of centralizing the images in the fovea (visual point in the retina) [34]. The individual directs the images to the retina's central point, by a physiological process named fixation reflex, through a feedback mechanism [35]. Beyond the sensory capacity, the oculomotor disponibility is necessary for the movement execution. Eyes whose movements are restricted (for mechanical causes, such as the restraining ones, or functional, as the muscular paralysis) will have reduced fusional extent, even though the sensory capacity of doing it still can be normal [36] English, German. In normal visual development, it's necessary that the brain receives signals coming from the retina in a clear way, received by the fovea in both eyes, simultaneously [37, 38].

The oculomotor disturbance, which can cause torticollis, is known as squint. This pathology is an extraocular musculature dysfunction, congenital or acquired, which has high prevalence in the population, varying from 2% to 4%. In specific squint studies in children the prevalence is 1,3% to 5,7%. There are numerous clinical presentations, and its treatment can be clinical or surgical [39, 40]. A study done in August of 2002, in a low-income population in Brasília - DF affirmed that 7,73% have squint, which is the cause of amblyopia (lazy eye) and limiting factor to the individual´s bio-psychosocial development [41, 42].

Six muscles promote the ocular movement action, and these are innervated by three pairs of cranial nerves [43]. The movements and ocular positional adjustments, such as looking left and right, up, and down and diagonally, or whichever combination between these movements, require a varied visual demand and a high precision coordination [44, 45]. The visual or oculomotor entrance, or even the combination of both, has primal importance in the postural regulation. The patient can present orthophoria (where the visual axis is in the fixed object) or heterophoria (when the visual axis is not aligned), these can be convergent, divergent, vertical, and torsional [46]. Currently a quantification in an orthoptic evaluation allows relating the main directions of the oculomotor muscles, correlating, and confronting with the one suggested in the postural exam [47].

In this context, the operations of the physical therapist have fundamental importance through the postural and oculomotor evaluations and the application of techniques, such as ocular physical therapy and the postural reeducation, which aims the motor recovery with adequate ocular positioning, sensory stimulus, and the posture´s correction. Therefore, this research aims to evaluate the prevalence of cervical postural alterations in patients with oculomotor disturbance, through eye motricity tests and postural exams, showing the correlation between both pathologies.

2. Material and methods

It was examined in september of 2006, on The Department of Orthoptics at Ophthalmology Prontoclinic of the city of Recife, referred by ophthalmologists from the clinic itself, in prior consultation, of Recife´s city hall SUS (Sistema Único de Saúde), (150) a hundred and fifty patients, (monthly average of attendance) to examine the ocular motility, of which (35) thirty five presented imported oculomotor disorders, these being selected and invented to participate the research. Of these, twenty four attended the postural exam, in October, accepting the participation in this study. The patients were from both genders, aged from 4 to 39 years old. The inclusive criteria to being a part of the research were: patients between the ages of four and fifty years old, carriers of oculomotor alteration and acquired cervical postural alterations. As the exclusive criteria, carrier patients of congenital postural disturbes - such as torticollis, traumatic causes and infectious causes; which present profound amblyopia (lower vision in one of the eyes), monocular or subnormal vision.

The extrinsic ocular motility evaluation was the first procedure using the evaluation form already established by the clinic: 1. Distance Visual Acuity (DVA) (55) - the measure of the amount of vision the patient has in each eye individually, using optotype table (optotype HV table with remote control) 5 meters away. 2. Cover Test (56) - alternate eye coverage measure, with or without prism, to evaluate the eyes ´ movements searching the image at a distance of 5m and of 35cm, in primary position, secondary and tertiary of the look. It was diagnosed as symmetry between the eyes (orthophoria) or converging/diverging/vertical type eye deviation. Prisms are utilized to quantify the deviation found. 3. Near Point of Convergence (NPC) (57) - a point is fixed 35cm away, bringing it closer to the eyes, requiring the individual to make an adduction movement with both eyes. It may find a normal, regular, weak or remote convergence. 4. Versions (binoculars rotations) (58): the eyes are encouraged to follow a fixation point, 35cm away, within the nine gaze positions, diagnosing if the extrinsic ocular musculature presents any restrictions, paralysis/paresthesia or important limitations. 5. Ocular dominance - prefered eye. 6. Hirschiberg and Krimisky: verify the type and measurement of the deviation through the pupillary reflex without prism and with prism respectively. 7. Stereopsis Test - presence or not of the depth perception (tridimensional vision- binocular fusional vision) through the lang test stereoscope. 8. Red Filter and Lights of Worth (RF) - diagnose fusion in both eyes, through the use of horizontal prism ruler. Oculomotor disturbances possibly found in the ocular motility test are included in table 1.

Table 1: Oculomotor disturbances.

Oculomotor disturbances	Abbreviations	Characteristics	Affected muscles	Restricted movements
Horizontal deviation Exodeviation	X, X(T), XT	Divergent deviation	Lateral rectus or Medial rectus	Adduction deficit
Horizontal deviation Esodeviation	E, E(T), ET	Convergent deviation	Medial rectus or Lateral rectus	Abduction deficit
Vertical deviations Hypertropia Hipotropia	H, H(T), HT	Negative vertical deviation E/D Positive vertical deviation D/E DVD- Dissociated vertical deviation	Superior and Inferior rectus or Superior and Inferior oblique	Depression or elevation deficit

Convergence insufficiency	IC	Adduction deficiency from the medium line	Medial rectus	Adduction deficit

Postural evaluation: Initially, a questionnaire was carried out with the main complaints, clinical history and patient´s personal history, relative to postural problems, to distance the possibility of joint problem and postural congenital, traumatics or infectious diseases. It used a previously evaluated form, based on postural assessments information according to Palmer (2000), chapter 4. The test was performed with the individual in an orthostatic position, in the front view, posterior and lateral, using a plumbline in the three positions (Figure 1). The individuals were examined in naked eye through photograph, evaluating if there was the presence of head inclination and rotation; pupillary and lip symmetry height of the shoulder girdle and shoulder blades; presence of scoliosis, kyphosis, lumbar hyperlordosis and head protrusion.

Figure 1. Postural assessment with wire plumb - front, rear view, and side respectively.

3. Results

In the general context the obtained results demonstrated that the oculomotor disturbers carrying individuals also presented postural alteration (Figure 2). From the 24 attended patients, it was 16 (66,6%) females and 08 (33,3%) males. In the ocular motility evaluation it was observed a percentage of: ophthalmologic visit; level of visual acuity, some executed without glasses for not having been prescribed by the ophthalmologist; use of glasses; performing treatment with oculomotor exercises; type of oculomotor disturb (see table 1), which may be associated with each other; extrinsic more affected ocular muscles, having accrued more than one muscle in the same eye and ocular dominance (preferred eye). See table 2.

Table 2: Ocular motricity evaluation.

Procedure	Number of cases	%
Visits to the ophthalmologist	24	100
Visual acuity:		
20/20 (AO)	19	79,16
20/30 (AO)	03	12,50

20/60 (AO)	02	8,33
Use of glasses	15	62,5
Treatment with oculomotor exercises	06	25
Types of oculomotor disturbances		
Orthophoria	02	8,33
Exodeviation	12	50
Esodeviation	09	37,5
Negative hypertropia - E/D	10	41,66
Positive hypertropia - D/E	04	16,66
Hypertropia - DVD	02	8,33
Convergence insufficiency	19	79,19
Most affected extrinsic muscles		
Lateral Rectus	12	50
Medial Rectus	09	37,5
Superior Oblique	11	45,83
Inferior Oblique	18	75
Obs: 1. The dysfunctions occured in more than one muscle in the same eye, at the same time. 2.The superior and inferior rectus muscles did not present dysfunctions.		
Ocular dominance		
Right eye	14	58,83
Left eye	10	41,66

The postural exam result was divided by the type of oculomotor disturbance. In simple exodeviations (XT), the biggest prevalence was head inclination to the left, the scoliosis and kyphosis; in exodeviation associated the hypertrophy (XT + HT). The prevalence was inclination of 10 heads to the right and head rotation to the left (see table 3).

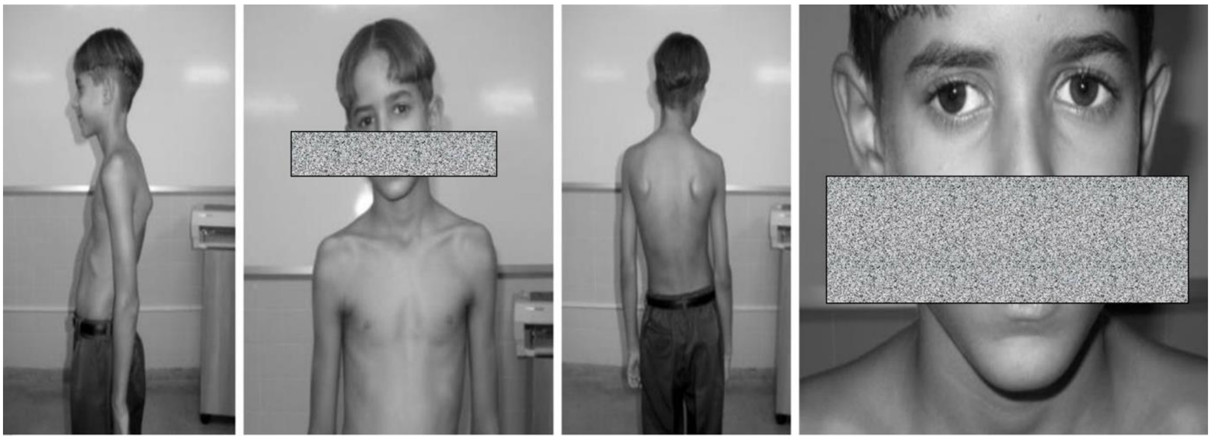

Figure 2. Nine-year-old child, who presented exodeviation (divergent deviation) with negative vertical deviation and convergence insufficiency in the ocular motility exam, and in the postural exam: scoliosis, kyphosis and PVC with head tilt to the right and pupillary plane and higher left lip edge.

Table 3: Exodeviation carriers (XT- divergent deviation) (n = 12; 50%).

Postural alterations	simple XT (n= 6)	XT + hypertrophy (HT) (n= 6)
Head inclination to the right	**n = 2 (33,33%)**	**n = 5 (83,33%)**
Head inclination to the left	**n = 5 (83,33%)**	**n = 1 (16,66%)**
Head rotation to the right	**n = 2 (33,33%)**	**-----**
Head rotation to the left	**-----**	**n = 5 (83,33%)**
Higher right pupillary base	**-----**	**-----**
Higher left pupillary base	**n = 3 (50%)**	**n = 3 (50%)**
Higher right lip edge	**-----**	**-----**
Higher left lip edge	**-----**	**n = 2 (33,33%)**
Weighbridge left	**n = 2 (33,33%)**	**n = 2 (33,33%)**
Weighbridge right	**n = 1 (16,66%)**	**n = 3 (50%)**
Both shoulders elevated	**n = 2 (33,33%)**	**-----**
Winged shoulder blades	**n = 2 (33,33%)**	**n = 1 (16,66%)**
Higher right scapula	**n = 2 (33,3%)**	**n = 1 (16,66%)**
Higher left scapula	**n = 2 (33,33%)**	**n = 2 (33,33%)**
Scoliosis	**n = 5 (83,33%)**	**4 (66,66%)**
Kyphosis	**n = 5 (83,33%)**	**n = 3 (50%)**

Lumbar hyperlordosis	**n = 3 (50%)**	**n = 2 (33,33%)**
Head protrusion	**n = 3 (50%)**	**n = 2 (33,33%)**

In the convergent deviations, all of them were associated with hypertrophy, the biggest prevalence's were scoliosis, lumbar lordosis and head inclination to the left which appeared in the three situations (see table 4).

Table 4: Esodeviation carriers (ET- convergent deviation) (n= 10 / 41.66%).

Postural alterations	ET + hypertropia (HT D/E) (n = 06 / 60%)	ET + hypertropia (HT E/D) (n= 03 / 30%)	ET + hypertropia DVD (n= 01 / 10%)
Head inclination to the right	n = 01 (16,66%)	n = 01 (33,33%)	------
Head inclination to the left	n = 03 (50%)	n = 01 (33,33%)	n=01 (10%)
Head rotation to the right	n = 02 (33,33%)	-----	------
Head rotation to the left	n = 03 (50%)	-----	-----
Right pupil base more elevated	n = 02 (33,33%)	n = 01 (33,33%)	-----
Left pupil base more elevated	n = 03 (50%)	n = 01 (33,33%)	-----
Right lip edge more elevated	-----	n = 01 (33,33%)	-----
Left lip edge more elevated	n = 01 (16,66%)	n = 01 (33,33%)	-----
Weighbridge to the left	n = 03 (50%)	n = 01 (33,33%)	-----
Weighbridge to the right	n = 02 (33,33%)	n = 01 (33,33%)	-----
Scapular winging	n = 01 (16,66%)	-----	-----
Higher right scapula	n = 02 (33,33%)	-----	-----
Higher left scapula	n = 01 (16,66%)	-----	-----
Scoliosis	n = 04 (66,66%)	n = 01 (33,33%)	n=01 (10%)
Kyphosis	n = 04 (66,66%)	n = 01 (33,33%)	-----
Lumbar hyperlordosis	n = 04 (66,66%)	n = 01 (33,33%)	n=01 (10%)
Head protrusion	n = 01 (16,66%)	-----	-----

The carrier individuals of orthophoria, however with convergence failure, also presented postural alterations, being the most accurate the right weighbridge presented in both patients (see table 5).

Table 5: Orthophoria carriers (without deviation) and with convergence insufficiency (n= 02 / 8,33%).

Alterations	n
Head inclination to the left	n = 1 (50%)
Weighbridge to the right	n = 2 (100%)
Higher left scapula	n = 1 (50%)
Scoliosis	n = 1 (50%)
Kyphosis	n = 1 (50%)

4. Discussion

There are few publications related to postural cervical alterations in oculomotor disturbs, however this study demonstrated the presence of several dysfunctions on segments responsible for posture in individuals with limitations, paresis, and paralysis in the ocular muscles. It is showed that the eye result of cephalic and ocular movements, aiming to centralize the images of the object on the fovea, through phasic and tonic movements of the head, contributing to the corporal balance, occurring with the interaction between the visual, labyrinthine, and proprioceptive systems, and that the investigation of the visual system, regarding its contribution to the maintenance of balance, is widely used [50]. The patients in this study presented oculomotor disturbances, which may be used as cervical postural compensations to maintain the images received on the retina in a binocular way and, therefore, having a large influence on the balance [50].

It was affirmed in a study about the relation between oculomotor system reflex and superior cervical that the adjustment of postural balance is from the labyrinthine system integrated with the ocular, cerebellar and proprioceptive information systems [48]. These Report the existing relation between the eye's movement and the muscle tension on the cervical region. This happens through the inputs from the vestibular nucleus complex that transmit head position information, associated with visual information coming from the cortex and the cerebellum in order to control the balance influence on the eye's muscles coordination and head position correction. The study in discussion shows ocular disturbances for instance: lower view, insufficient convergence and heterotrophs that brings the patient to use postural compensations as protection to a better quality visual [48].

In research, it was reported a frequent vicious head position condition (VHP) is the eye adjustment for the purpose of compensating for a squint, assuring a normal binocular view. This is in response to the loss of freedom of eye positional adjustments, implying that the problem is not primarily in the neck but in the head. It also affirmed in his entitle article: Torticollis – Vicious Head Position, which to diagnose this pathology requires an excellent anamnesis: complaints and observations, to deepen the difference between orthopedic and ocular causes; being of orthopedic cause the voluntary or passive head movements being in a restricted way, while of an ocular cause in a freeway. The study's results demonstrated a high prevalence of horizontal, vertical and convergence oculomotor deviations on postural compensations [21].

The presence of vicious head positions in the squint presented on the carriers of exodeviation associated with hypertrophies confirms that the ocular motricity deficit leads the patient to try to compensate it with the appropriate head posture for the pathology, shifting it to the side of the paretic muscle, this happens with the intention of avoiding diplopia and confusion of the received images through the retina [51].

The head inclination and rotation in the individuals evaluated, relative to the VHP - vicious head position obtained a high percentage in both convergent [E] and divergent [XT] deviations, these being associated with vertical deviations [hypertrophies - HT]. In this context, severe paretic strabismus cases, whether this is traumatic, ophthalmological or neurological, can lead the patient to adopt a vicious head position with the intention of getting rid of diplopia and the confusion of images.as well as, when a kid, avoid suppression and development of an ambliopia (low view In one of the eyes) [52].

One of the most prevalent disturbances presented in this study was the convergence insufficiency associated with or without heterotrophs. In the patients with orthophoria, there was presence of weighbridges, head inclination, scoliosis, and kyphosis. In this reasoning, insufficient convergence may cause an unbalance of the postural muscle groups, which leads to the appearance of several joint pathologies that will not be caused but consequences of imbalances of segments responsible for the posture. This ocular disturbance could lead to shoulder girdle weigher and shoulders' rotation. Furthermore, the exteroception is essentially dependent on the rods of peripheral vision, and proprioception is linked to extraocular muscle activities and the oculocephalogyric pathways that subject the neck and shoulder muscles to the eyes [53].

Moreover, it was reported that from the alterations found in the cervical segment, an increase in lordosis, rectification, and protrusion of the C7 are detected; alterations in the head position including lateral inclinations and front projections. This is due to the presence of a poor posture caused for an anormal relation between corporeal structures with excessive solicitation of the support elements decreasing balance and body support base these alterations are the most prevalent in the postural evaluation in this search, proving that the oculomotor disorder is related to changes in the upper cervical. Due to the marked presence of alterations in the segments that are responsible for posture, shown in the result, it is noticed that the patients demonstrate a deficiency in the corporal balance, and they report, in the previously carried through questionnaire, the presence of pains in the back and in the region of the neck [49].

In a clinic point of view, the upright posture stabilization requires the integration of three senses obtained by vestibular, visual, and somatosensory [proprioceptive] receptors. Vision measures the orientation of the eyes and head with respect to surrounding objects and plays an important role in maintaining postural balance [54]. Besides the present study confirms the existence of alterations postures in carrier individuals of oculomotors disturbs, the literature is still scarce, in this perspective it is clear the need for further research and publications to clarify the association of the two pathologies.

5. Conclusion

The present study makes it clear that patients who carry oculomotors disturbed, also present cervical postural alterations, which demonstrate a meaningful percentual results to alterations on the segments responsible to the maintenance of postural balance. These alterations vary according to type of the oculomotor disturbance, however all of them may lead the patients to orthopedics problems and long-term pain symptoms. Therefore, these patients should be referred to specialists for a postural assessment and, if possible, undergo postural reeducation treatment and treatment of the extrinsic eye muscles. It can be through oculomotor exercises or strabismus surgeries, when the ocular deviation is of important motor limitation that will compromise aesthetics and visual functionality. The need for physical therapy intervention in conjunction with ophthalmology is clear.

Funding: None.

Research Ethics Committee Approval: The proposal was approved before its start by the Ethics Committee in Research of Universidade Católica de Pernambuco under the protocol CAAE 0019.0.0096.000-06 and consent was obtained from the patient for their images to be published.

Acknowledgments: None.

Conflicts of Interest: We have no conflicts of interest to disclose.

Supplementary Materials: None.

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