The comparison of head and neck alignment in children with visual and hearing impairments and its relation with anthropometrical dimensions

Hasan Daneshmandi [1], Ali Shamsi Majalan [2], Mostafa Babakhani [3*], Karanian F [4]

1. Associate Professor, Faculty of Physical Education and Sport Sciences, University of Guilan, Rasht, Iran.
2. Assistant Professor, Faculty of Physical Education and Sports Sciences, University of Guilan, Rasht, Iran.
3. MSc, Faculty of Physical Education and Sports Sciences, University of Guilan, Rasht, Iran.
4. MSc, Sport management, Faculty of Physical Education and Sports Sciences, University of Guilan, Rasht, Iran.

A B S T R A C T

Purpose: The aim of this study was to compare head and neck alignment in children with visual and hearing impairments and its relation with anthropometrical parameters.

Methods: The study was a descriptive, correlational analysis within which the relations between dependent and independent variables have been studied. Thirty children with poor vision, 30 children with hearing loss and finally 30 healthy ones ranged 6-12 years old were selected randomly. Anteroposterior and mediolateral photographs of the neck were obtained to check forward head and torticollis postures. Anthropometric parameters (head, neck and thorax circumference, neck, shoulder and thorax width, neck length, the distance from tragus to sternal notch and sitting-height) were measured. Statistical analysis of data was performed by 1-way ANOVA and Pearson correlation coefficient.

Results: The statistical results indicated that forward head angle was less in the visually impaired group than the group with hearing loss (P = 0.001) and the healthy group (P = 0.017). The lateral flexion angle was more in the group with hearing loss than the healthy group (P = 0.001). There is also a positive significant correlation between head circumference (P = 0.025), neck length (P = 0.001), sternal notch-tragus distance (P = 0.003), and sitting-height (P = 0.014) with forward head posture. No significant relation was observed between other anthropometrical parameters with structural profile variable (Forward head and torticollis).

Conclusion: The results of this study indicate that visual and hearing impairments can affect the head and neck alignment of children and this alignment has a significant relation with some of the anthropometrical dimensions. Therefore, it is necessary to pay more attention to treatment exercises in order to correct and improve body posture and changed anthropometrical dimensions in children with visual and hearing impairments.

1. Introduction

Disability is an abnormal complication subject which is seen in different forms in societies. Considerable population of every society consist of disabled individuals. The disabled individuals are divided into 3 categories: sensory group, physical group, and mental group. Sensory disabled individuals are divided into visual and hearing groups [1].

According to the estimation of the world health organization (WHO), there were about 40 to 45 million blind people and thrice as much people with poor vision all

* Corresponding Author:
Mostafa Babakhani, MSc
Address: Faculty of Physical Education and Sport Sciences, University of Guilan, Rasht, Iran.
Phone: +98(936)9127295
Email: mostafa.babakhani@ymail.com

over the world, in 2004. Most of these people live in low income countries.

The world health organization has reported that the prevalence of blindness and low vision impairment in different societies at 0.3% to 5.6% [2]. According to the information obtained from students' screening in different regions of Iran in 2007, the prevalence of vision impairment among students of the first grade of elementary school was 4.7%, third grade of elementary school 3.8%, first grade of guidance school 5.8%, and students of first grade of high school at 4.1% [3]. In another study carried out in Tehran, it was estimated that the prevalence of myopia was 7.2% in children aged 5-15 years [4]. It has been reported that the prevalence of myopia in children aged 7-15 and 14-18 years is 3.4% and 3.3%, respectively [5].

On the other hand, hearing loss is a neurosensory disorder. More than 120 million people throughout the world suffer from this disorder. One in every 1000 children was born with congenital hearing loss. This loss is more common in Asian children. It is reported 2.6 cases in every 1000 birth and 0.7 cases in every 1000 birth in non-Asian children.

This disorder incurs almost $150 million cost every year. One of the purposes of the World Health Organization is to encourage countries to prevent deafness by performing international plans such as reducing diagnosis age and doing screening tests at birth [6]. The results of studies indicate that physical postures in children with hearing loss disorder are different with healthy children. After examining postural deformities of 54 deaf children aged 10 to 16 years, it was determined that all subjects had postural abnormalities in sagittal and frontal planes [7]. The study of structural profile in children aged 6 to 12 years showed that forward head angle in blind group is less than that angle in the hearing loss and healthy groups, and lateral flexion angle in blind and deaf children was similar and more than that of the healthy group [8]. The results obtained from studying the physical posture of 19 children with myopia showed that reduction in neck angle is significantly related with vision reduction [9].

The researchers believe that proper body posture normally depends on placement of center of gravity of different parts of body in an appropriate situation [10]. Appropriate situation in head and neck occurs when the head is balanced with the least muscular power. The gravity line should coincide with edge of ear from the lateral view, the neck should have normal arch, from the

posterior view, and the vertical line should coincide with head medial line and be placed on spinous process of cervical vertebra [11]. Forward head posture is one of the common postural deformities and is categorized as syndromes of chronic pain. In this situation, the head is inclined to the back and the neck bends down on thorax, deep muscles of head are shortened like suboccipital muscles and they are weakened against deep muscles of neck. The neck muscles (because of having high density of muscle spindle) have the main role in providing neck proprioceptive information.

Any change in the function of these muscles as a result of inappropriate posture of the head, will have negative effect on the movement and balance control. Since the head is placed near or outside of hearing level, it causes anterior movement of the body center and gravity line and accordingly affects individual balance [12]. Although postural deformities are not necessarily signs of disease, they can bring about mental problems and secondary complications [13]. On the other hand, the studies on physical deformities show that individuals with different anthropometrical dimensions are subject to some postural deformities.

In a study, which investigated the anatomical alignment of trunk and upper limbs in relation to anthropometrical dimensions of the athletes, the results indicate that there are relations among sitting height, vertebral column length, arms' length and distance of two acromions with kyphosis and lordosis. The results of other studies showed that there is no significant relation between variables of weight, sitting height and deformities (kyphosis and lordosis), however, the relation between standing height and lordosis was significant. There was also positive and significant relation between length of neck and forward head deformities [15].

Therefore, studying the influencing factors on the incidence of postural deformities has a considerable importance. It seems that weakness of loss of vision or hearing can affect incidence of some musculoskeletal disorders. However, there is little information about physical posture of people with visual and auditory disorders, especially with regard to Iranian children. Considering the prevalence of sensory disorders in our country and its effects on life of individuals, it is necessary to do further researches in this regard.

2. Materials and Methods

The current study is a correlational research; the data have been gathered through field study. In this study, 90

boy students were enrolled. Thirty students with low vision, another 30 students with low hearing impairment who were studying in specific centers and 30 healthy ones (from age viewpoint) were selected randomly and from three provinces of Tehran, Guilan, and Ilam. The samples were collected after referring to school and specifying students with visual impairment (students wearing glasses).

Then, those having myopia were specified and selected. The low vision students were selected using their medical files and students with hearing impairment up to 60 db were selected for the research. The inclusion criteria for boy students were age range from 6 to 12 years and the exclusion criteria were absolute deafness, multiple disabilities, diseases such as respiratory and heart problems, orthopedic and joint problems like neck ache, backache, and obvious differences in length of organs. At first a session was held with the students' parents and the purpose of study and its stages were explicitly expressed. All subjects participated voluntarily and consent forms were obtained from their parents.
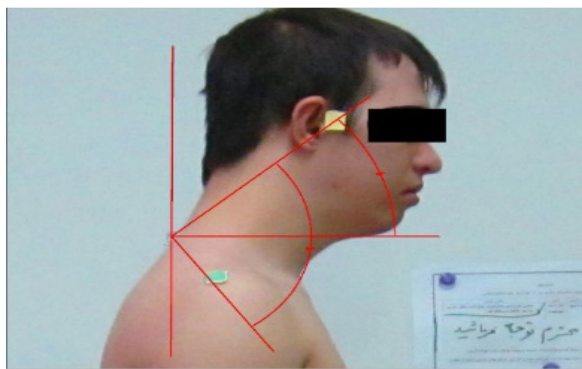
PHYSICAL TREA†MENTS

Figure 1. Measurement method of forward head.

Method of measuring head angle in sagittal plane (Forward head)

At first, the prominence of spinous process of the seventh cervical vertebrae and tragus process were identified and marked. The subjects were asked to stand in normal position and to look forward. The examiner stood with one meter distance and took photos using digital camera SX1SI in sagittal plane. A line was drawn between the seventh cervical vertebrae and tragus by AutoCad. Then, the angle between the drawn line and horizon line was calculated [9, 15]. Forward head refers to a position in which the tragus process is before the hypothetical plumb line. In a normal position, the plumb line passes through the tragus process, acromion process and greater trochanter. Its normal angle is 45-55 degree; more than

PHYSICAL TREA†MENTS

Figure 2. Method of measuring head lateral flexion.

55 degree is considered as a decrease in cervical lordosis and less than 49 degree is regarded as forward head complication [16].

Method of measuring torticollis or lateral flexion

Imaging method was used in order to measure torticollis. The subject was photographed in a standing position from frontal view by a digital camera and the linear angle which connects the earlobe of both ears was measured by horizon line using AutoCad 2011 [9, 17].In a standing position and from backward viewpoint, the head must be straight so that the gravity line passes through the center of occipital line and over cervical vertebral column. If this line does not coincide with the occipital bone or is bended toward different sides, it is recognized as torticollis [18].

Measurement of anthropometrical dimensions

In this study, the following tools were used: a standard and flexible tape with accuracy of 0.1 cm, caliper made in China with 0.02 mm error, a 30-cm flexible ruler, Kidos. The head, neck, and thorax circumference weremeasured by a tape, width of neck, shoulder, and thorax were measured using caliper, neck length by a flexible ruler, and finally, sternal notch-tragus distance by imaging method from lateral view.

In order to measure the length of the neck, the flexible ruler was tangent from the second cervical vertebrae to the seventh vertebrae and the length of neck was measured and registered in cm [15].

In order to measure sternal notch-tragus distance, the subject was placed beside a tape, which was installed vertically on the wall after specifying acromion process and tragus. The examiner took photos of the subject using digital camera in frontal level. The distance between horizon line and the markers were measured and reg-

Table 1. Individual particulars of subjects (Number=30).

Variable	Low vision group Mean±SD	Low hearing Mean±SD	Healthy group Mean±SD
Age (y)	8.75 ± 1.1	9.4 ± 0.85	8.75 ± 1.1
Height (cm)	128.57 ± 7.32	135.53 ± 8.2	130.6 ± 8.4
Weight (Kg)	28.7 ± 7.7	31.8 ± 7.9	29 ± 6.92
Body Mass Index	17.13 ± 3.13	17 ± 3	16.63 ± 2.9

PHYSICAL TREATMENTS

istered in AutoCad in cm [4, 19]. The head circumference was measured by a tape placed over eyebrow line (frontal) and the occipital protuberance (backward) was measured and registered in cm by slowly pressing the two sides of the tape [20]. The neck circumference was measured and registered using a tape, placed over the neck and below the laryngeal protuberance, its length was perpendicular to the neck length such that the tape was not completely horizontal [4, 20].

The width of the subject's neck was measured and registered in cm using caliper [14, 20]. The width of thorax is the distance between the sixth rib which is measured using a caliper at standing position so that the arms are moved far away on frontal plane [20, 4, 14]. The thorax circumference was measured using a tape, placed in the middle of the sternum in the space between the 4th rib at the end of exhalation [4, 20]. The subject was sitting on the edge of the desk for measuring the sitting height and the distance of the subject's head to edge of the desk was measured using ruler and tape [14, 20].

The data were analyzed using 1-way ANOVA and Scheffe test using SPSS software, version 21. The significance level was 0.05. Pearson correlation coefficient was used in order to investigate correlation between anthropometrical dimensions with postural abnormalities.

3. Results

Information relating to individual particulars of subjects (age, height, IMB) and data description of measured variable has been reported in Tables 1 and 2, respectively.

According to the obtained results in Table 4, it is observed that there is a significant relationship between head circumference (P = 0.025), neck length (P = 0.001), sternal notch-tragus distance (P = 0.003), and the sitting height (P = 0.014) with forward head abnormalities.

4. Discusion

The aim of this study was to compare head and neck alignment in children with visual and hearing impairments and its relation with anthropometrical parameters. According to the results obtained from this study, the forward head angle was lower in low hearing and healthy groups and the lateral flexion angle was higher in low hearing group compared to the other groups. Regarding the anthropometrical dimensions with postural abnormalities it was seen that there is significant correlation between head circumference, neck length, sternal notch-tragus distance and sitting height with forward head abnormalities.

However, no significant correlation was observed between other anthropometrical dimensions with forward head and torticollis. The normal range of forward head angle is 49-55 degree, and a lower angle is considered as forward head complication [16]. Considering the obtained results, the angle between the seventh cervical vertebrae and tragus process with horizon line was significantly lower in low vision group compared to other two groups. The results of the present study correlates with other studies [8, 9, 21, 22]. Having investigated structural profile in children aged 6 to 12 years with sensory disorders, Ali reported a significant difference in forward head angle among the subjects. The forward head angle was lower in children with visual disorders compared to other groups [8]. Kamali, 2002 found significant correlation between two variables of forward head and eye refraction problems.

Those having vision disorders such as myopia suffering more from forward head [21]. Ray and his colleagues concluded in their study that vision disorder had negative effect on postural stability [22]. There were different factors involved in the maintenance of proper posture, especially in maintaining the status of head and neck placement in space. Vision, labyrinthine, muscular, and proprioceptive impulses constantly warn the individuals of their body posture. These factors often cause

Table 2. Data description of measured variables.

Variable	Low vision group Mean±SD	Low hearing Mean±SD	Healthy group Mean±SD
Head circumference (cm)	51.9 ± 1.7	51.5 ± 1.49	52.02 ± 1.45
Neck circumference (cm)	27.3 ± 2.2	27.9 ± 1.96	26.9 ± 1.7
Neck width (cm)	8.3 ± 0.9	8.78 ± 0.87	8.45 ± 0.83
Neck length (cm)	7.1 ± 0.36	7.8 ± 0.4	7.72 ± 0.37
Shoulder width (cm)	24.25 ± 3.03	26.05 ± 2.62	23.9 ± 2.41
Thorax width (cm)	17.94 ± 2.7	19.5 ± 2.61	17.26 ± 1.64
Thorax circumference (cm)	64.14 ± 7.5	67.96 ± 7.47	63.6 ± 5.8
Acromion- Tragus (cm)	22.26 ± 2.9	25.18 ± 2.71	23.8 ± 2.8
Sitting height (cm)	69.8 ± 4.3	74.21 ± 5.5	71.78 ± 3.14
Forward head (cm)	46.23 ± 7.5	51.53 ± 6.2	51.27 ± 6.1
Body Mass Index	177.6 ± 2.1	176.3 ± 2.71	178.87 ± 2.08

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unconscious comparative movements for maintaining balance. In case of disorder in any system (especially vision reflex) the skull and body will be stricken with postural changes [22]. However, the results of this study are inconsistent with findings of Salem [24], [25] and the young Kaykhai, 2013.

Salem and his colleagues simultaneously studied the correlation between deprivations from vision stimuli with head posture. In this study, the normal status was studied in the health group in a room and the results obtained were compared to the similar findings of these subjects in a complete dark room. This study indicated that the head posture responded to vision stimuli and in the absence of this stimulus, the individuals are inclined to have hair extension [24]. In order to justify this difference it can be said that Salem and his colleagues carried out their study on normal people.

In his study, the subjects were deprived of vision stimuli (darkness) while subjects of the present study had myopia. In this disorder, light rays were centralized in front of the retina and the ciliary muscles were completely loosened. Light waves that come from an object at far distance are centralized before retina and as a result these people will have their eyes crossed to see the objects better and this will change head and neck position and will draw them forward. As time goes by these changes will result in functional changes in musculoskeletal system and then will bring about muscle imbalance and postural abnormalities.

Radhakrishnan, and colleagues studied head posture and its changes in two groups who had vision disorders such as myopia and hyperopia. The head posture was measured by simultaneously taking two photos in two different directions (before and beside) using a digital camera. The results showed that there is no significant difference in head posture between two groups. Keykhah Javan in his study regarding the correlation between some anthropometrical dimensions of trunk and vision power with upper crossed syndrome indicated that there was no significant correlation between vision power and upper crossed syndrome [3].

The reason for the inconsistent results in our study can be ascribed to different methods of measurement, age range, and sample size. In the results obtained by the study of Keykhah Javan, the difference in the number of samples made the correlation of vision disorder with forward head complication insignificant. There was a significant correlation in lateral flexion in different groups. The lateral flexion was higher in low hearing group compared to the other groups. The results of the present study is consistent with results of the study carried out by Hasani [26] and Ali [8, 26] in this regard. We can justify this matter by stating that the main sources of sensory information for satisfactory control of posture are somatosensory, vestibular, and visual systems. Vestibular system is a double function organ in which cochlea is responsible for hearing and vestibule is responsible for balance and posture control.

However, hearing ability is its secondary property and the first responsibility of hearing organ is maintenance

Table 3. Results of correlation test for relation between anthropometrical factors with structural profile variables.

Variable	Forward head		Torticollis	
	Correlation coefficient	P-value	Correlation coefficient	P-value
Head circumference	0.236	0.025*	0.123	0.247
Neck circumference	0.046	0.669	-0.019	0.859
Neck length	0.458	0.001*	0.108	0.311
Neck width	0.107	0.316	0.006	0.953
Shoulder width	-0.107	0.855	-0.054	0.610
Thorax circumference	-0.019	0.773	-0.041	0.701
Thorax width	0.031	0.845	-0.055	0.605
Sternal notch-tragus distance	0.021	0.003*	-0.031	0.775
Sitting height	0.314	0.014*	-0.042	0.695
Standing height	0.259	0.222	-0.025	0.816
Body Mass Index	0.130	0.486	0.044	0.6802

*indicates significant difference (level of significance 0.05)

PHYSICAL TREA†MENTS

and adjustment of posture and balance. Due to the anatomical closeness of these two systems, related changes in both systems are considered normal [22].

It is normal for children with hearing impairment to suffer from vestibular problems and this can be justified considering the role of vestibular system in maintaining head posture. Children who had hearing impairments develop their postural strategies through choosing a certain posture in order to overcome or compensate their balance problems and obtain physical balance. This will cause several postural changes in their vertebral column. Therefore, it is expected that disorder in vestibular system unconsciously result in lateral flexion in individuals with hearing impairment [8].

On the other hand, there was a significant difference regarding the correlation between anthropometrical dimensions and postural abnormalities in the subjects of the present study in several variables. There was a significant correlation between head circumference, neck length, sternal notch-tragus distance, sitting height with forward head abnormalities.

But there was no significant correlation between other anthropometrical factors and variables of forward head and torticollis. Since the efficacy of anthropometrical dimensions and abnormalities on each other is higher in lower limbs than the upper limbs due to the factors such as weight bearing and closed chain movements in biomechanics, there are a few studies concerning the correlation of anthropometrical dimensions with abnor-

malities in upper organs [14]. The results of Keykhah Javan' study regarding this matter indicated that there is no significant correlation between anthropometrical dimensions and disorders like forward head, kyphosis, and round neck. However, the neck length with forward head and round neck have significant correlations in such a way that students with vision impairments have shorter neck with respect to healthy individuals [3]. This is consistent with the results of the present study. In this regard, we can mention myopia disorder, which changes head and neck posture, draws it forward, and brings about muscular contractions in head and neck. In these conditions, neck anterior muscles are stretched and posterior muscles are shortened.

This will increase cervical lordosis and simultaneously increases closeness to vertebrae spinous process and finally shortens the length of neck. Keshavarz Moghaddam [15] found a positive and significant correlation between length of the neck and forward head abnormalities. The individuals with higher length of neck were more prone to forward head complication. He believes that when the length of neck is high (due to torque arm raise), the head will twist forward more. As a result, posterior neck muscles will have more activity to establish balance and to inactive this forward torque, finally neck posterior muscles will be weakened and forward head complication will happen.

This finding is inconsistent in some aspects with the results of present study. In order to justify this difference, it can be argued that the subject of Keshavarz Moghad-

dam study were workers employed in industry and all the time they sat while they had bent forward. Therefore, weight of their upper limbs and sitting posture always affected vertebrae column, especially the neck and drew it to the forward and down.

As time goes by, this condition would stretch and weaken posterior deep and superficial muscles of neck and at the same time would open the cervical vertebrae, draw off spinous process of vertebrae and compresse neck anterior part. Finally, this position would result in forward head posture and cervical lordosis. This type of disorder will decrease cervical lordosis and inhibits backward swirl of skull [18].

It seems that these factors increased the length of the neck in these individuals. While in the present study, the subjects had myopia and its nature was discussed in detail, it can be said that the mechanisms followed by myopia were completely in contrary to Keshavarz Moghaddam's study. The subjects of the current study had forward head with increase in cervical lordosis, which simultaneously caused the backward swirl of skull and shortened length of the neck [18]. In the present study, no significant correlation was found regarding the correlation between the length of the neck with torticollis complication, which is consistent with Keshavarz Moghaddam's study.

Regarding the variables of sitting height, sternal notch-tragus distance and their correlation with postural abnormalities, the findings of the study indicated that individuals with forward head posture, had shorter sitting height and shorter sternal notch-tragus distance as well compared to other groups. The results were inconsistent with Keykhah Javan study.

This can be justified by stating that forward head deviation together with increase in cervical lordosis causes changes in head, neck and vertebral column and due to the correlation and cohesion, which exist between vertebral column and upper limbs, any changes in any part of vertebral column will bring about changes in other bows of vertebral column and upper limbs and in turn will cause secondary abnormality. The results of the present study indicated obvious decrease in the length of several anthropometrical dimensions such as neck length, sitting height, sternal notch-tragus distance, which was probably due to the following vision disorder and simultaneous forward head.

Recommendation

Considering the results from the present study, it can be concluded that head and neck alignment in children can be affected by vision and hearing impairment and this alignment has a significant correlation with some anthropometrical dimensions. Thus, considering the fact that it is nearly impossible to correct acquired physical deficiencies and appearance of the body, especially in old ages, we recommend that teachers and instructors besides working on issues related to teaching, have a proper plan and treatment exercise in order to remove and develop postural abnormalities in children. In this regard, they can take effective measures for the health of this group of society and can guarantee their healthier life.

Acknowledgement:

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