

Binocular vision and abnormal head posture in children when watching television

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Abstract

• **AIM:** To determine the association between the binocular vision and an abnormal head posture (AHP) when watching television (TV) in children 7-14y of age.

• **METHODS:** Fifty normal children in the normal group and 52 children with an AHP when watching TV in the AHP group were tested for spherical equivalents, far and near fusional convergence (FC) and fusional divergence (FD) amplitudes, near point of convergence, far and near heterophoria, accommodative convergence/accommodation ratio and stereoacuity. The values of these tests were compared between the two groups. The independent *t* test was applied at a confidence level of 95%.

• **RESULTS:** The far and near FC amplitudes and far FD amplitudes were lower in the AHP group (the far FC amplitudes: break point $13.6 \pm 5.4^{\Delta}$, recovery point $8.7 \pm 5.4^{\Delta}$. The near FC amplitudes: break point $14.5 \pm 7.3^{\Delta}$, recovery point $10.3 \pm 5.1^{\Delta}$. The far FD amplitudes: break point $3.9 \pm 2.7^{\Delta}$, recovery point $2.6 \pm 2.3^{\Delta}$) compared with those in the normal group (the far FC amplitudes: break point $19.1 \pm 6.2^{\Delta}$, recovery point $12.4 \pm 4.5^{\Delta}$. The near FC amplitudes: break point $22.3 \pm 8.0^{\Delta}$, recovery point $16.1 \pm 5.7^{\Delta}$. The far FD amplitudes: break point $7.0 \pm 2.1^{\Delta}$, recovery point $4.6 \pm 1.9^{\Delta}$). Other tests presented no statistically significant differences.

• **CONCLUSION:** An association between the reduced FC and FD amplitudes and the AHP in children when watching TV is proposed in the study. This kind of AHP is considered to be an anomalous manifestation which appears in a part of puerile patients of fusional vergence dysfunction.

• **KEYWORDS:** binocular vision; fusional convergence; fusional divergence; abnormal head posture

INTRODUCTION

Abnormal head posture (AHP) is a common condition in children, with an estimated incidence of 1.3%^[1]. It may be adopted for ocular or nonocular reasons. The most common ocular reason is incomitant strabismus^[2]. Less common causes include nystagmus, compensation for refractive errors, visual field defects, eyelid anomalies and cosmetic reasons^[2]. An AHP can take the form of head tilt, head turn, chin up, chin down or a combination depending on the specific etiology. Because the etiology is not always obvious, these patients must be carefully evaluated.

We often find children in out-patient clinics whose parents complain that their children always have a head turned when watching television (TV), while normal when walking, playing or doing homework. A detailed check is made and overt ophthalmological and systematic problems are excluded. Sometimes the AHP is attributed to refractive errors^[3]. There are indeed some children with AHP that have refractive errors, but there are still many children with good uncorrected visual acuity and without obvious refractive errors. Little attention has been focused on this anomalous manifestation.

For incomitant strabismus, the AHP is usually assumed in the interest of obtaining binocular cooperation and avoiding diplopia^[4]. Children with an AHP when watching TV may also have concerns with binocular vision. The aim of this paper is to determine the possible association between binocular function and AHP when watching TV in children 7-14y of age.

SUBJECTS AND METHODS

This prospective study was conducted by Henan Eye Institute & Henan Eye Hospital from November 2008 to December 2013. Subjects were aged 7-14y. The research adhered to the tenets of the Declaration of Helsinki. Every child that participated received a standardized comprehensive eye examination by a licensed eye care professional (optometrist or ophthalmologist) that was experienced in working with young children.

The children with complaints of AHP were required to watch a 20min cartoon on a 21-inch TV in a quiet room. The distance from the TV set to the subject was 2.5 m. The sound level was 50 dB. Doctors observed through a camera in the next room. If the subject carried out a head turn, the direction, degree and the time it appeared were recorded. The degree of head turn was measured with an arc perimeter. After the AHP appeared, it was observed for a few minutes. When it was stable, a perimeter was put just behind the subject. The scale in the perimeter pointed by the perpendicular at the center of the subject's forehead was recorded as the degree of head turn.

Inclusion criteria for the study included healthy children 7-14 years old that had an AHP when watching TV for the previous 1 to 6mo. The AHP took the form of a head turn. When watching a cartoon in the office, the AHP appeared within 15min. The angle of the head turn was 20 to 45. The direction of the head turn was either to the right or left. The uncorrected visual acuity was $\geq 20/20$ in both eyes. The cycloplegic refractive errors by atropine in each eye were ≤ 1.50 diopters (D) hypermetropia, ≤ 0.50 D myopia (0 to -0.50 D), ≤ 0.50 D astigmatism or ≤ 0.50 D anisometropia in spherical equivalent.

Exclusion criteria included overt ophthalmological problems, incomitant deviation (manifest or latent), manifest comitant deviation, manifest or latent nystagmus, history of strabismus surgery, previous refractive surgery, dysfunction of the auditory system, cervical vertebrae and neck muscles and other systematic abnormalities. Overt ophthalmological problems were excluded through slit lamp and fundus examinations. Manifest deviation was investigated using the unilateral cover test at 5 m and 33 cm^[5]. Deviations in the 9 diagnostic positions of gaze were obtained with the prism and cover test at 5 m and 33 cm^[5]. The fixation object is a line of the Snellen optotype E corresponding to the highest visual acuity in distance and a fixation stick of 20/30 letters at a near distance. A difference in the magnitude of deviation of $>5^\Delta$ is indicative of an incomitant deviation^[6], which was excluded in the study.

The study also enrolled children aged 7-14 years old as normal controls. The same ophthalmological and systematic examinations were made as mentioned above. The inclusion and exclusion criteria were the same except that they did not exhibit an AHP when watching TV.

On first referral, the children eligible for the study were tested. Tests included far and near positive and negative fusional vergence [fusional convergence (FC) and fusional divergence (FD)] amplitudes, near point of convergence (NPC), far and near heterophoria, accommodative convergence/accommodation (AC/A) ratio and stereoacuity. During these tests, the heterophoria was measured first, followed by divergence amplitudes and then convergence amplitudes and others^[7]. Each type of test was administered by a different

examiner. Examiners were masked as to whether subjects were in the AHP group or normal group (subjects in the AHP group have a head turned only when watching TV. So it is feasible.). For the subjects in the AHP group, the head was straightened during the tests. For each test, three measurements were obtained and averaged for each subject.

The tests that were administered and the methodology is described below: far and near FC and FD amplitudes were measured with bar prisms and the strength was increased slowly and stepwise^[8]. For both near and far distances, the FD was measured with base-in prisms and FC with base-out prisms. Base-in ranges were measured before base-out to avoid vergence adaptation^[9]. For far measurements, the subject was situated at 5 m from the fixation object (a line of the Snellen optotype E corresponding to the highest visual acuity)^[10]. For near measurements, the subject was situated at 40 cm from the fixation object (a fixation stick of 20/30 letters)^[8]. The prism bar with its corresponding base was placed in front of the subject until the subject first reported horizontal diplopia (break value). Then the prism power was reduced until a single image was seen (recovery value).

Different targets have been used for NPC testing, such as an accommodative target, a penlight (PL), a penlight with a red glass (PLRG) before one eye and a PL with red-green glasses^[11-13]. Scheiman *et al*^[11] compared the different methods and suggested that clinical diagnosis can be made with any of the targets, although AT appears to provide the best precision. In the text, the NPC was determined by placing an AT (a fixation stick of 20/30 letters) at 40 cm in the midsagittal plane of the child's head. For the test, a ruler was supported at the centre of the forehead of the subject at the level of the brow. As the subject fixated on the AT, it was moved toward the subject at a speed of 2-3 cm/s until the examiner detected a break in the fusion or the subject announced seeing double. This was the measurement for the break in fusion. Next, the AT was moved away at the same speed until the eyes appeared to be realigned, indicating a recovery of fusion. At all times, the examiner observed the position of the eyes as well as the break and recovery of fusion in order to achieve an objective measurement.

The method to measure heterophoria was the prism alternate cover test^[8]. To perform this test, a cover was placed alternately in front of each eye while the patient maintained fixation. For measuring distance heterophoria, the subject was situated at 5 m from the fixation object (a line of the Snellen optotype E corresponding to the highest visual acuity). For measuring near heterophoria, the subject was situated at 40 cm from the fixation object (a fixation stick of 20/30 letters). A prism was placed in the appropriate direction in front of one eye. The prism strength was increased until the movement was neutralized.

The gradient method for calculating the AC/A ratio uses the change in vergence angle at a given distance of 40 cm in

association with a change in the stimulus to accommodation produced by ophthalmic lenses. The subject was asked to fixate on a fixation stick of 20/30 letters and the heterophoria was measured. Then -2.00 D lenses were placed in front of each eye [14]. The heterophoria was remeasured while the patient viewed the same target through the lenses and the ratio was calculated as follows [15]: $AC/A = \frac{\Delta_1 - \Delta_0}{D}$, where Δ_0 is the original deviation, Δ_1 is the deviation with the lens, and D is the power of the lens.

Stereoacuity was detected with the Titmus stereo test. The test stereogram was held at a distance of 40 cm from the subject. The subject was asked to view the Wirt rings through polarizing filters and determine which one in each successive group appeared to "pop out of the page". This procedure was repeated until two mistakes were made successively. The threshold stereoacuity level was recorded in seconds of arc.

Parameters of the subjects that did or did not have an AHP when watching TV were calculated respectively. Children without an AHP were assigned to the normal group and those exhibiting an AHP were assigned to the AHP group. The independent *t*-test was applied at a confidence level of 95%. The data were analyzed using the statistical package SPSS15.0.

RESULTS

A total of 148 subjects were evaluated. Forty-six were excluded from the study: 6 revealed an intermittent exotropia, 2 presented an incomitant deviation, 18 didn't show a visible AHP when watching cartoon in the clinic, 6 showed a combination of head turn and head tilt or chin down, and 14 were excluded because of lack of cooperation. One hundred and two subjects were enrolled in the study, comprising 50 children (27 males and 23 females) in the normal group and 52 children (31 males and 21 females) in the AHP group. While watching cartoons in the clinic, all the children in the AHP group exhibited a head turn. Twenty children turned their heads to the right and 32 children to the left. The degree and the time the head turn appeared were 25.2 ± 10.7 min and 7.9 ± 4.8 min on average, respectively.

In the overall sample, all variables displayed a normal Gaussian distribution after a Smirnov-Kolmogorov goodness-of-fit test. The values compared between the two groups are listed in Table 1. Results showed that there were no statistically significant differences between the two groups in age, spherical equivalents, near FD amplitudes (break and recovery point), NPC (break and recovery point), far and near horizontal phoria, far and near vertical phoria, stereoacuity and AC/A ratio. There were statistically significant differences between the two groups for far and near FC amplitudes (break and recovery point; $P < 0.05$) and far FD amplitudes (break and recovery point; $P < 0.05$) after the ANOVA. The far and near FC amplitudes and far FD

Table 1 Parameters evaluated for the normal and AHP group and *t*-test ($P < 0.05$)

Parameters	Normal	AHP	<i>t</i>	$\bar{x} \pm s$ <i>P</i>
Age (a)	11.7±3.4	11.1±2.9	1.461	0.152
spherical equivalents (D)	0.4±0.7	0.5±0.5	-0.164	0.871
Far FC (break point) (Δ)	19.1±6.2	13.6±5.4	-5.720	0.000
Far FC (recovery point) (Δ)	12.4±4.5	8.7±5.4	-3.761	0.001
Far FD (break point) (Δ)	7.0±2.1	3.9±2.7	2.351	0.024
Far FD (recovery point) (Δ)	4.6±1.9	2.6±2.3	2.439	0.020
Near FC (break point) (Δ)	22.3±8.0	14.5±7.3	2.085	0.044
Near FC (recovery point) (Δ)	16.1±5.7	10.3±5.1	2.891	0.006
Near FD (break point) (Δ)	12.2±3.7	10.8±4.5	-1.054	0.298
Near FD (recovery point) (Δ)	9.3±4.0	8.4±3.9	-1.385	0.174
NPC (break point) (cm)	7.1±4.2	6.7±5.0	-0.756	0.454
NPC (recovery point) (cm)	11.5±7.3	11.8±8.5	0.602	0.551
Far esophoria (Δ)	0.5±2.6	0.6±3.1	0.804	0.432
Near exophoria (Δ)	-0.6±3.2	-1.0±3.7	-1.112	0.280
Far vertical phoria (Δ)	0.0±0.2	0.0±0.3	0.877	0.392
Near vertical phoria (Δ)	0.0±0.2	0.0±0.4	0.748	0.463
AC/A ratio (Δ/D)	4.7±1.4	4.3±1.7	0.911	0.383
Stereoacuity (seconds of arc)	62.4±26.1	59.7±22.7	0.677	0.518

FC: Fusional convergence; FD: Fusional divergence; NPC: Near point of convergence; AC/A: Accommodative convergence/accommodation.

amplitudes were significantly lower in the AHP group compared with those in the normal group.

DISCUSSION

In our study, some ocular or nonocular reasons for AHP, such as strabismus, nystagmus, refractive errors and hearing impairment, were eliminated. The main finding of our study was lower far and near FC amplitudes and far FD amplitudes in the AHP group compared with the normal group and the normal values reported [12]. These findings demonstrated that AHP in our study was associated with an abnormal FC and FD.

We regard the reduced FC and FD amplitudes as a kind of fusional vergence dysfunction (FVD). This is a condition in which there is no significant phoria at either far or near vision, but the horizontal fusional vergence ranges are reduced in both convergence and divergence directions [16]. Their zone of clear single binocular vision was small. In our study, patients in the AHP group had normal far and near horizontal or vertical phoria. The FC amplitudes were reduced significantly at both far and near distances. While the FD amplitudes were only reduced for far distances compared with the normal group. The difference may be related to the population and ethnicity measured. The data in the study was measured in a puerile population of Asian, which may differ from the general population and other ethnicity. Patients with FVD often have normal AC/A ratios [16], which supports our findings. NPC was normal in the AHP group, which can rule out the diagnosis of convergence insufficiency (CI).

According to the modified Duane classification system [17], FVD is a kind of vergence dysfunction. The etiology is uncertain. One report ranks the prevalence of this condition just below those of CI and convergence excess [18]. The

patients often first notice it when asthenopia occurs. A slow vergence system is responsible for sustaining CSBV during prolonged watching. It is the failure of the slow vergence system that results in asthenopia. Symptoms are relieved when one eye is closed^[19]. Suppression may also develop in some patients^[19]. We consider the AHP in the AHP group as an appearance of asthenopia when reduced FC and FD amplitudes cannot meet the visual demands for watching TV. It is presumed that children in the study turned heads to induce suppression or play a role similar to closing one eye. Then discomforts can be avoided when watching TV.

Usually, asthenopic symptoms are less frequent in distance vision than in near vision. Though children in the AHP group had reduced far and near FC and far FD amplitudes, few symptoms were reported when they were doing close work or watching still distant objects. These children have normal phorias. According to Sheard's criterion^[20], there is no symptom when the amount of heterophoria is less than half of the opposing FC in reserve. Moreover, the impulse of vergences depends on many factors, one of which is the size of the targets^[21]. As an object gets closer, its retinal images become larger, thus fusion becomes easier^[22]. However, pictures are always moving when watching TV. When watching moving objects, more distress is put on fusion than when watching still objects^[19]. The additional load on the visual system may result in symptoms. The relation between asthenopia and performance is governed, to some extent, by pain thresholds. Some children demonstrating objective signs of FVD do not experience symptoms. However, later on, when the visual demands placed upon them are sufficiently stressful, discomfort may appear.

According to our study, we can propose an association between a binocular vision disorder and AHP in children when watching TV. This disorder is shown as the lower far and near FC amplitudes and far FD amplitudes. We consider it a kind of FVD and the AHP is an anomalous manifestation of asthenopia that appears in some puerile patients. Early detection of clinically significant nonstrabismic vergence anomalies is important. Without treatment, some of these may decompensate and become strabismic, resulting in the loss of stereopsis and the development of suppression. We therefore suggest that children with an AHP must be carefully evaluated. Besides well-known causes, such as strabismus and refractive errors, anomalous binocular function should be considered.

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