Factors Modulating School Myopia

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Abstract: To examine the correlation between visual acuity and refractive error of elementary school students with (1) parental vision status; (2) dietary history; (3) visual habits; and (4)in- and out-door activities. 694 (of 731) students from one urban elementary school participated in the study.They underwent visual acuity test and distance retinoscopy together with completion of a multi-item questionnaire with the help of their parents and teachers. There was a decrease in the number of students with 1.0 or better vision from over 50% in Grade 1 to around 20% in Grade 6. At the same time, those with 0.2 or worse vision increased from Grades 1 to 6. No difference was noted between males and females in refractive error. And in parallel to the change in visual acuity, there was a decrease in students with -1D or less and an increase in students with -1D or more of refractive error from Grades 1 to 6. These visual parameters were also associated with mother's(but not father's) refractive error, ingestion of table grapes, near work, and indoor exercises, but not with outdoor activities on weekdays, weekends, or during vacation time. In the absence of efficacious myopia control at present, progression of school myopia maybe minimized through practice of visual hygiene and reduction of indoor hours.

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1. Introduction

School myopia is a perennial problem in Taiwan. The Dept of Health reported that in 1986, 1990, 1995, 2000, 2006, and 2011 the respective prevalence of myopia in the first Graders was 3, 6.5, 12.8, 20.4, 19.6, 21.5%, and in the 6th Graders, 27.5, 35.2, 55.8, 60.6, 61.8, and 65.8 [1]. It was increasing clear that the onset of school myopia had become younger and that which was accompanied by increasing severity [2-3]. In fact, the prevalence of myopia was found to be 3.0, 4.2, 4.7, and 12.2% at ages 3, 4, 5, and 6 years, respectively [4]. In the past two decades, the prevention of myopia and its progression has principally been based on medically induced cycloplegia, specifically the use of atropine [5-9]. In one study in Taiwan, multifocal spectacles have been deemed ineffective [6]. The atropine efficacy studies have been done with relatively small numbers of participants usually on a short-term basis of between 1-2 years - except a 5 year study on 20 high myopes [8]. And the results indeed show limited reduction of myopia the progression, but not total cessation.

If the most efficacious treatment to date, i.e., the cycloplegic or atropine therapy, still cannot eliminate school myopia, then other contributing factors must continue to facilitate the increase in ocular axial length, i.e., the underlying cause of the increase in myopia [3,6,10-12]. Studies originating from Taiwan have already shown hereditary and familial components in the development of school myopia [13-15] upon which the environmental factors interact. And it is already well-known that extended outdoor activities can be protective [16-18]. On the other hand, extensive near work, also a major promoter of school myopia [19], has not received intense scrutiny. The same applies to the dietary history which in fact has not been closely examined at all.

In the present study, we have therefore examined the following possible contributing factors: (1) parental refractive status; (2) dietary history; (3) visual habits; and (4) in- and out-door activities by analyzing detailed multiple-item questionnaire completed by the participants and the results reported here.

2. Methodology

As a school-wide vision screening, 731 students from one elementary school in the City of Taichung,

with the consent of their parents, participated in the study. 37 did not complete the questionnaire and were excluded from the final data analysis. The number of total cases analyzed was 694 (Table 1). All students were in good health with only one physically/ mentally impaired student in each Grade and one each with an illness in the 3rd, 4th and 5th Grades.

Table 1: Number of participating students, Grades 1-6; total=694

	Grade 1		Grade 2		Grade 3	
Gender	M	F	M	F	M	F
No	52	43	58	49	66	51
Total	96		107		117	
	Grade 4		Grade 5		Grade 6	
Gender	M	F	M	F	M	F
No	66	70	75	64	51	49
Total	136		139		100	

Visual parameters: All students underwent visual acuity testing using the Snellen E charts at a distance of 6 m. To facilitate the examination process, screening with an autorefractor (Speedy-1, Nicon, Japan) was done first and the data used as the starting point of retinoscopy. Distance retinoscopy was employed to minimize accommodation. It is well-known that non-cycloplegic auto-refraction of children tends to result in over-estimations of myopia [20]. For random sampling prevalence studies involving relatively small numbers of subjects, cycloplegia is crucial [21]. However, in large-scale eye screening such as that in the present study, this is impractical. Not only the limitation in manpower, the dark irises of Taiwanese children would require high doses of cycloplegics and the short-acting tropicamide often used in the surveys in Taiwan [22] appears inadequate, so the dose-timing and the over-dosing for cycloplegic refraction remain a difficulty. In this study, we have used non-cycloplegic auto-refraction [23] supplemented with fogged retinoscopy [24] and retinoscopy with a distant fixation target [20] and have determined that the over-estimate by auto-refraction was less than 5%. Both techniques therefore can be used in mass screening. These tests were performed and finished in 5% school days aided by 3rd and 4th optometry students under faculty supervision in addition to experienced clinicians.

Questionnaire: All participants were given a multi-page questionnaire to be completed with the assistance of their parents and teachers. The questions included (A) the visual status of parents: normal vision or otherwise owing to hyperopia/ myopia/ astigmatism/ amblyopia/ visual handicap – based on self-reported prescription power of current optical correction as well as vision status; (B) dietary history including the intake quantity and frequency of food items such as meats, fruits, vegetables, grains, and beverages as well as nutritional supplements; (C) visual habits including the duration and types of near work and physical activities plus the characteristics of visual environments; and (D) outdoor UV protection: the types and occasion.

Statistical analysis

The data were analyzed with, Independent-Sampling t-test, Point bi-serial correlation, Spearman correlation, and Partial correlation with the SPSS 17 package.

3. Results

3.1 Visual parameters

The results of visual acuity are shown in Table 2; There was a significant difference of those with 1.0 vision between Grades 2-3 with OD: t=3.444, p=0.001; and OS: t=3.224, p=0.001. In general, there was a decrease in the number of students with 1.0 or better vision from Grades 1 to 6, from over 50% to around 20%. In contrast, those with 0.2 or worse increased from Grades 1 to 6.

And the refractive error is summarized in Table 3; The "<-1D" groups included hypeopic values. The results indicated no difference between males and females. And in parallel to the change in visual acuity (Table 2), there was a decrease in students with less than -1D and an increase in students with -1D or more of refractive error from Grades 1 through 6.

Table 2: Change in visual acuity from Grades 1-6

		OD			
Visual Acuity		≤0.1	0.2-0.5	0.6-0.9	≥1.0
Grade 1	Number	2	13	27	53
	Percentage	2.11%	13.68%	28.42%	55.79%
Grade 2	Number	3	18	31	55
	Percentage	2.80%	16.82%	28.97%	51.40%
Grade 3	Number	6	26	36	49
	Percentage	5.13%	22.22%	30.77%	41.88%
Grade 4	Number	10	50	29	47
	Percentage	7.35%	36.76%	21.32%	34.56%
Grade 5	Number	18	46	29	46
	Percentage	12.95%	33.09%	20.86%	33.09%
Grade 6	Number	17	45	18	20
	Percentage	17.00%	45.00%	18.00%	20.00%
		OS			
Visual Acuity		≤0.1	0.2-0.5	0.6-0.9	≥1.0
Grade 1	Number	2	12	28	53
	Percentage	2.11%	12.63%	29.47%	55.79%
Grade 2	Number	1	14	34	58
	Percentage	0.93%	13.08%	31.78%	54.21%
Grade 3	Number	10	26	33	48
	Percentage	8.55%	22.22%	28.21%	41.03%
Grade 4	Number	7	40	37	52
	Percentage	5.15%	29.41%	27.21%	38.24%
Grade 5	Number	16	42	34	47
	Percentage	11.51%	30.22%	24.46%	33.81%
Grade 6	Number	13	38	27	22
	Percentage	13.00%	38.00%	27.00%	22.00%

Table 3: Refractive error based on distance retinoscopy (SE=spherical equivalent) in Grades 1-6

			OD		
		SE	<-1D	-1D ~ -6D	>-6D
Grade 1	M	Number (Percentage)	44 (84.6%)	8 (15.4%)	0 (0%)
	F	Number (Percentage)	38 (88.4%)	5 (11.6%)	0 (0%)
	Total	Number (Percentage)	82 (86.3%)	13 (13.7%)	0 (0%)
Grade 2	M	Number (Percentage)	47 (81.0%)	11 (19.0%)	0 (0%)
	F	Number (Percentage)	37 (75.5%)	12 (24.5%)	0 (0%)
	Total	Number (Percentage)	84 (78.5%)	23 (21.5%)	0 (0%)
Grade 3	M	Number (Percentage)	39 (59.1%)	27 (40.9%)	0 (0%)
	F	Number (Percentage)	31 (60.8%)	20 (39.2%)	0 (0%)
	Total	Number (Percentage)	70 (59.8%)	47 (40.2%)	0 (0%)
Grade 4	M	Number (Percentage)	28 (42.4%)	37 (56.1%)	0 (0%)
	F	Number (Percentage)	42 (60.0%)	27 (38.6%)	1 (1.4%)
	Total	Number (Percentage)	70 (51.5%)	64 (47.1%)	2 (1.4%)
Grade 5	M	Number (Percentage)	39 (52.0%)	34 (45.3%)	2 (2.7%)
	F	Number (Percentage)	31 (48.4%)	32 (50.0%)	1 (1.6%)
	Total	Number (Percentage)	70 (50.4%)	66 (47.5%)	3 (2.1%)
Grade 6	M	Number (Percentage)	24 (47.1%)	25 (49.0%)	2 (3.9%)
	F	Number (Percentage)	19 (38.8%)	28 (57.1%)	2 (4.1%)
	Total	Number (Percentage)	43 (43.0%)	53 (53.0%)	4 (4%)
			OS		
		SE	<-1D	-1D ~ -6D	>-6D
Grade 1	M	Number (Percentage)	43 (82.7%)	9 (17.3%)	0 (0%)
	F	Number (Percentage)	39 (90.7%)	4 (9.3%)	0 (0%)
	Total	Number (Percentage)	82 (86.3%)	13 (13.7%)	0 (0%)
Grade 2	M	Number (Percentage)	45 (77.6%)	13 (22.4%)	0 (0%)
	F	Number (Percentage)	35 (71.4%)	14 (28.6%)	0 (0%)
	Total	Number (Percentage)	80 (74.8%)	27 (25.2%)	0 (0%)
Grade 3	M	Number (Percentage)	38 (57.6%)	28 (42.4%)	0 (0%)
	F	Number (Percentage)	27 (52.9%)	23 (45.1%)	1 (2.0%)
	Total	Number (Percentage)	65 (55.6%)	51 (43.6%)	1 (0.8%)
Grade 4	M	Number (Percentage)	30 (45.5%)	35 (53.0%)	1 (1.5%)
	F	Number (Percentage)	38 (54.3%)	31 (44.3%)	1 (1.4%)
	Total	Number (Percentage)	68 (50%)	66 (48.6%)	2 (1.4%)
Grade 5	M	Number (Percentage)	36 (48.0%)	38 (50.7%)	1 (1.5%)
	F	Number (Percentage)	26 (40.6%)	36 (56.3%)	2 (3.1%)
	Total	Number (Percentage)	62 (44.6%)	74 (53.2%)	3 (2.2%)
Grade 6	M	Number (Percentage)	17 (33.3%)	31 (60.8%)	3 (5.9%)
	F	Number (Percentage)	19 (38.8%)	28 (57.1%)	2 (4.1%)
	Total	Number (Percentage)	36 (36.0%)	59 (59.0%)	5 (5.0%)

3.2 Questionnaire analysis

(A)Visual status of parents: There is a significant correlation between mother's subnormal vision and the student's lower visual acuity values and higher spherical equivalents. In contrast, no such correlation with father's vision.

Table 4A: Parental visual status based on current refractive error and vision

	Father	Mother
Normal	266 (38.3%)	238 (34.3%)
Hyperopic	32 (4.6%)	28 (4.03%)
Myopic	360 (51.9%)	399 (57.5%)
Astigmatic	27 (3.9%)	24 (3.5%)
Myopic+astigmatic	74 (10.7%)	79 (11.3%)
Amblyopic	7 (1.01%)	3 (0.43%)
Visually handicapped	2 (0.29%)	2 (0.29%)

Table 4B: Correlation between parental vision and the refractive status of the offspring

		VA (OD)	VA (OS)	SE (OD)	SE (OS)
Father's vision	Correlation	.288	.286	.251	.247
	Significance	.191	.201	.453	.484
Mother's vision	Correlation	.618*	.611*	.603*	.591*
	Significance	.000	.001	.001	.002

VA: visual acuity ; SE: spherical equivalent

*significant correlation with p= 0 to 0.002.

(B)Dietary history: After adjusting for gender, grade, and age, no correlation was found between visual acuity/spherical equivalent and the intake of (i) meats; (ii) vegetables and grains; (iii) poultry and fish; or (iv) frequency of beverage intake and (v) sugar contents of the beverages. Unexpectedly, from 29 categories of food items, one - the frequency of ingesting table grapes (never, <once/week, 1-2 times/week, 3-4 times/week, or daily) -showed a strong positive correlation with visual acuity (r=0.574; p=0.011) and spherical equivalent (r=0.485; p=0.042).

(C)Visual habits: The analysis was adjusted for gender, grade, and age. Correlation between visual

acuity/spherical equivalent with various physical and environmental factors is shown below: It shows a strong negative correlation of the visual parameters with reading. In contrast, proper visual hygiene (e.g., reading distance, rests) was associated with a positive correlation(Table 5). The weak association with indoor physical activities remains to be further investigated.

There was, however, no correlation between visual acuity/spherical equivalent and (i) weekday after-school static or physical activities; (ii) duration of TV watching at all times; (iii) duration of outdoor activities at all times; (iv) illumination of desks; (v) room illumination for TV watching; (vi) illumination for computer use; (vii) heights of reading desk and chair; (viii) heights of computer desk and chair; (ix) rest after 30-min TV viewing; or (x) activities before sleep.

Table 5: Summary of correlation analyses; N.C.= no correlation

Items	Visual acuity	Spherical equivalent
Textbook reading/ writing, weekdays (<30 min to >3 hrs)	r= -0.578; p=0.010	r= -0.493; p=0.033
Leisure reading, weekdays (<30 min to >3 hrs)	r= -0.612; p=0.003	r= -0.518; p=0.017
Reading: weekends /vacations (<30 min to >3 hrs)	r= -0.556; p=0.012	r= -0.556; p=0.012
Indoor physical exercises, weekdays (<30 min to >3 hrs)	r=0.475; p=0.047	N.C.
Weekend/vacation indoor physical exercises (<30 min to >3 hrs)	r=0.485; p=0.042	N.C.
Duration of computer use (<30 min to >3 hrs)	N.C. weekdays, weekends, and vacations	r= -0.504; p=0.019, vacations
Reading distance > 30cm (never to always, 5 rating levels)	r=0.582; p=0.009	r=0.540; p=0.010
Rest after 30-min reading (never to always, 5 rating levels)	r=0.630; p=0.000	r=0.508; p=0.013
Use of different Rx for daily and near activities (never to always, 5 rating levels)	r=0.830; p=0.000	r=0.786; p=0.000
Hours of sleep (<6 to >10 hrs,5 grades)	r=0.692; p=0.000	r=0.492; p=0.034
Distance from TV (from inadequate to excellent, 5 rating levels)	N.C.	r=0.491; p=0.036

(D)Outdoor protection: After adjusting for gender, grade, and age, no correlation was found between visual acuity and (i) sunglasses wear or (ii) lenses with anti-UV coating or UVresistant contact lenses. Also, no correlation between the spherical equivalent and (i) sunglasses wear or (ii) use of broad-rimmed hats or sun parasols.

On the other hand, correlation was found between visual acuity and (i) positively with the wear of regular spectacles (r=0.911; p=0.00) and (ii) negatively with the use of hats/parasols (r= -0.477; p=0.045). Also between spherical equivalent and (i) the wear of regular spectacles (r=0.915; p=0.000) or (ii) UV-resistant lenses (r=0.660; p=0.000).

The common element appears to be outdoor wear of daily spectacles in the preservation of visual acuity and refractive error.

4. Discussion

Cycloplegic therapy remains the only choice for slowing myopia progression at present [5-9, 25] even though long-term efficacy and side-effects are both still unclear. In fact, the acceptance of this therapy in Taiwan is not absolute at all [26]. A re-examination of hereditary and environmental factors is therefore necessary. There are in fact some previous unknown albeit notable results in the present study:

(1) A correlation of visual parameters with the mother's, but not the father's, visual status (Table 4B). This is in part in agreement with a recent study from Taiwan which reported a parental association [18] and with another from Singapore, the increasing odds of myopia development if both parents were myopic [27].

(2) Table grapes, among an exhaustive list of food items (29 categories), appeared to associate with less change in the visual parameters. This is probably the only nutritional correlation reported to date.

(3) Among the several environmental elements, such as TV watching and room lighting, outdoor activities also did not affect the visual parameters. It should be qualified that the elementary school at which the present study was performed was located in an urban setting. This result is in harmony with that reported in Ref [22] –also done in an urban area. The outdoor activities in the rural areas[16, 18] where much lower myopia prevalence was observed maybe owing to activities quite different from that in the urban schools.

Since the cycloplegics cannot totally remove myopia, other factors, i.e., those related to visual hygiene must be re-examined and the results put in practice. For example, from Table 5, it maybe advantageous for the students to adhere to the

common sense approach to (i) reduce the time spent on reading and writing, take a break after every 30 min, and read at >30 cm; (ii) wear glasses outdoors; and (iii) exercise indoors and get enough sleep. In addition, reading with a near aid (perhaps other than multi-focal lenses [6]) appears beneficial. It remains unknown how effective these measures, when combined, will reduce the potential of myopization. Perhaps in the near future, good visual hygiene with optical aids that avoid, e.g., peripheral hyperopic defocusing caused by conventional lenses [28] can replace or be worn in conjunction with cycloplegic therapy at an early stage [26]. It is, however, abundantly clear that after two decades, a truly effective myopia therapy still awaits development.

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