

1 **Diplopic versus non-diplopic strabismus: effects on functional vision and eye-related quality**  
2 **of life in adolescents**

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11 **Word count:** 1100 words (max 1100 for short report)

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13 **Running head:** Eye-related quality of life with diplopia

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24 **Summary** (165 words; max 200)

25 **Twenty adolescents with diplopic strabismus (12-17 years old) and 20 with non-diplopic**  
26 **strabismus (matched to diplopic subjects for direction and magnitude of ocular deviation)**  
27 **completed the Pediatric Eye Questionnaire (PedEyeQ). Children completed the Child**  
28 **PedEyeQ and one parent for each child completed the Proxy PedEyeQ and Parent PedEyeQ.**  
29 **PedEyeQ Rasch domain scores were calculated and converted to a 0 (worst) to 100 (best)**  
30 **scale. Distributions of domain scores were compared between diplopic and non-diplopic**  
31 **cohorts by using Wilcoxon tests. Diplopic adolescents had significantly lower Child PedEyeQ**  
32 **scores on: Functional Vision (72 vs 90; P=.008), Bothered by Eyes/Vision (65 vs 90; P=.009),**  
33 **and Frustration/Worry (53 vs 75; P<.001) domains. There was no difference on the Child**  
34 **Social domain (85 vs 90; P=.22). Interestingly, Proxy and Parent PedEyeQ scores were similar**  
35 **between diplopic and non-diplopic cohorts (P>.06 for each comparison). These findings**  
36 **highlight the importance of addressing diplopia when managing childhood strabismus.**  
37 **Parents may be less aware of the additional impact of diplopia on their children.**

38 **INTRODUCTION**

39           Although strabismus is associated with reduced eye-related quality of life (ER-QOL) and  
40 functional vision in children and adolescents,<sup>1-4</sup> the impact of diplopia on strabismic children and  
41 adolescents has not been studied. In the present study, we used the Pediatric Eye Questionnaire  
42 (PedEyeQ)<sup>1</sup> to evaluate ER-QOL and functional vision in adolescents with diplopic strabismus  
43 versus adolescents with non-diplopic strabismus.

44  
45 **METHODS**

46           Approval was obtained from Institutional Review Boards at Mayo Clinic, Rochester,  
47 Minnesota and University of Texas Southwestern Medical Center, Dallas, Texas. All procedures  
48 and data collection were conducted in a manner compliant with the Health Insurance Portability and  
49 Accountability Act and all research procedures adhered to the tenets of the Declaration of Helsinki.

50 **Subjects**

51           An overall cohort of 71 adolescents with strabismus (aged 12 to 17 years old) were  
52 prospectively enrolled, from which a total of 20 diplopic children were identified and 20 matched  
53 non-diplopic children were selected. All had a primary diagnosis of strabismus, allowing coexisting  
54 refractive error, amblyopia, fusion maldevelopment nystagmus, but excluding visual field defect,  
55 cataract, infantile nystagmus syndrome, glaucoma, retinal disorders, optic nerve disease, uveitis,  
56 craniofacial disorders, lid anomalies, cerebral visual impairment, and systemic syndromes affecting  
57 the eyes. Previous strabismus surgery was allowed if more than 6 months prior to assessment.

58 **Diplopia status**

59           Diplopia status was determined based on review of the history in the medical record. Data  
60 were not sufficiently granular to allow classification of diplopia frequency, so subjects were

61 classified as diplopic if current diplopia was noted at the examination when the PedEyeQ was  
62 completed and non-diplopic if there was no record of diplopia.

63 **Diplopic and non-diplopic cohorts**

64 Each subject with diplopia (n=20) was matched to a subject without diplopia but with the  
65 same direction of primary deviation (esotropia, exotropia, or hypertropia) and similar magnitude of  
66 deviation (first matching the largest of distance or near simultaneous prism cover test [SPCT]  
67 measures, then largest of distance or near prism and alternate cover test [PACT] measures).

68 **The Pediatric Eye Questionnaire (PedEyeQ)**

69 Children completed the Child 12-17 year PedEyeQ, and 1 parent or legal guardian for each  
70 child completed the Proxy 12-17 year PedEyeQ (parent assessment of child) and Parent PedEyeQ  
71 (impact on the parent themselves).<sup>5</sup> The Child 12-17 PedEyeQ comprises one Functional Vision  
72 domain and three ER-QOL domains (Bothered by Eyes/Vision, Social, Frustration/Worry). The  
73 Proxy 12-17 year PedEyeQ consists of one Functional Vision domain and four ER-QOL domains  
74 (Bothered by Eyes/Vision, Social, Frustration/Worry, Eye-care<sup>5</sup>) and the Parent PedEyeQ has four  
75 distinct quality of life domains (Impact on Parent/Family, Worry about Child's Eye Condition,  
76 Worry about Child's Self-perception and Interactions, and Worry about Child's Visual Function<sup>5</sup>).  
77 Each questionnaire utilizes a 3-point frequency scale ("Never," "Sometimes," "All of the time") for  
78 responses. Questionnaires, scoring algorithms, and look-up tables are freely available at:  
79 [https://public.jaeb.org/pedig/view/Other\\_Forms](https://public.jaeb.org/pedig/view/Other_Forms).

80 **Analysis**

81 For each subject, on each PedEyeQ domain, Rasch scores were calculated using look-up  
82 tables ([https://public.jaeb.org/pedig/view/Other\\_Forms](https://public.jaeb.org/pedig/view/Other_Forms)) and then converted to 0 (worst) to 100

83 (best) for interpretation. Distributions were compared between diplopic and non-diplopic cohorts  
84 using Wilcoxon tests. Mean differences with 95% confidence intervals (CI) were also calculated.

85

## 86 **RESULTS**

### 87 **Subjects**

88 Demographics and clinical characteristics for the 20 diplopic and 20 matched non-diplopic  
89 adolescents with strabismus are shown in Table 1. Eight (20%) of 40 had been previously reported  
90 in a study of the overall impact of strabismus.<sup>1</sup>

### 91 **PedEyeQ scores**

92 Child PedEyeQ domain scores were significantly lower for adolescents with diplopia than  
93 for those without diplopia on the Functional Vision domain (72 vs 90; P=.008; mean difference: -  
94 15, 95% CI -26 to -3), Bothered by Eyes/Vision domain (65 vs 90; P=.009; mean difference -21,  
95 95% CI -34 to -7), and Frustration/Worry domain (53 vs 75; P<.001; mean difference -22, 95% -32  
96 to -12) (Table 2). There was no difference on the Child Social domain (85 vs 90; P=.22, Table 2).  
97 Proxy PedEyeQ scores were similar between diplopic and non-diplopic cohorts for all five domains  
98 (P>.06 for each domain). For the Parent PedEyeQ, scores were similar between diplopic and non-  
99 diplopic cohorts (P>.42 for each domain, Table 2).

100

## 101 **DISCUSSION**

102 In this prospective evaluation of adolescents with strabismus, we found the presence of  
103 diplopia resulted in significantly lower functional vision and ER-QOL scores by self-report (Child  
104 PedEyeQ). Interestingly, by proxy report, parents generally did not perceive worse functional vision

105 or ER-QOL with diplopia. There were also no significant differences when evaluating impact on the  
106 parents themselves (Parent PedEyeQ).

107 Although several previous studies document reduced quality of life in children and/or  
108 adolescents with strabismus,<sup>1-4</sup> none of which we are aware have evaluated whether strabismus with  
109 diplopia differs from strabismus without diplopia. Studies in adults with strabismus have shown  
110 greater deficits in function related quality of life domains with diplopia,<sup>6</sup> and also that the presence  
111 of diplopia following strabismus surgery is associated with failure to improve quality of life.<sup>7</sup> Data  
112 from the present study provide evidence of the additional impact of diplopia on quality of life in  
113 adolescents.

114 The greater impact of diplopia on quality of life, above and beyond the overall impact of  
115 strabismus, may have implications for management. We suggest that it would be helpful to  
116 specifically identify the presence and frequency of diplopia, for example using formal assessment  
117 tools such as the Diplopia Questionnaire.<sup>8</sup> Also, it is important to either formally (e.g., using the  
118 PedEyeQ<sup>5</sup>) or informally determine how diplopia is impacting a child in their every-day life, and to  
119 be aware that the child's perspective may differ from that of the parent. We found that differences  
120 between diplopic and non-diplopic cohorts, reported by the child, were not paralleled by proxy  
121 report, indicating that parents may be less aware of the additional difficulties encountered by  
122 children with diplopia. In addition, treatment plans should aim to specifically address diplopia.  
123 Previous studies in adults have confirmed that successful treatment of diplopic strabismus with  
124 prism<sup>9</sup> or with surgery,<sup>10</sup> improves quality of life. We anticipate this improvement may also occur  
125 in adolescents with diplopic strabismus.

126 There are some limitations to our study. The absence of differences using the Proxy and  
127 Parent PedEyeQ may be due to the relatively small sample size. Nevertheless, numbers were

128 sufficient to find differences using the Child PedEyeQ. In addition, it is possible that associations  
129 with diplopia were confounded by other clinical or demographic factors not evaluated in this study  
130 although patient groups were matched for the key factors of direction and magnitude of ocular  
131 deviation. Also, we did not have sufficient sample size to evaluate the influence of sex and age.

132           In 12- to 17-year-olds the presence of diplopia accompanying strabismus is associated with  
133 greater deficits in functional vision and ER-QOL, than in strabismus without diplopia. These data  
134 highlight the importance of identifying and addressing diplopia in adolescents.

135 **ACKNOWLEDGEMENTS**

136 **Funding/Support:** Financial assistance for this study came from National Institutes of Health  
137 Grants EY024333 (JMH, PI & EEB, Co-I), EY011751 (JMH) and EY022313 (EEB), and Mayo  
138 Foundation, Rochester, Minnesota.

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140 **Role of the Funder/Sponsor:** The funding sources had no role in the design and conduct of the  
141 study; collection, management, analysis, and interpretation of the data; preparation, review, or  
142 approval of the manuscript; and decision to submit the manuscript for publication.

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167 **Table 1:** Clinical Characteristics of Diplopic and Non-Diplopic Adolescents (aged 12-17 years)  
 168 with Strabismus.  
 169

Demographics and clinical characteristics	Diplopic (n=20)	Non-diplopic (n=20)
Sex, N (%) Female	10 (50)	12 (60)
Median age (range) in years	15 (12-17)	14 (12-17)
Median (range) largest angle SPCT*	6 (0-35) PD	6 (0-40) PD
Median (range) largest angle PACT*	17 (6-40) PD	12 (3-50) PD
Primary esodeviation	11/20 (55%)	11/20 (55%)
Acquired non-accommodative	5/11	4/11
Partially accommodative	2/11	2/11
Infantile	1/11	3/11
Consecutive	0/11	1/11
6 <sup>th</sup> nerve palsy	2/11	0/11
Decompensated fully accommodative	1/11	1/11
Primary exodeviation	4/20 (20%)	4/20 (20%)
Intermittent exotropia	3/4	3/4
Consecutive	1/4	1/4
Primary hyperdeviation	5/20 (25%)	5/20 (25%)
Dissociated vertical deviation	2/5	4/5
4 <sup>th</sup> nerve palsy	1/5	0/5
3 <sup>rd</sup> nerve palsy	1/5	0/5
Orbital floor fracture	1/5	0/5
Non-specific	0/5	1/5
Amblyopia present	2/20 (10%)	8/20 (40%)
Previous strabismus surgery	8/20 (40%)	13/20 (65%)

170 SPCT= simultaneous prism cover test

171 PACT = prism and alternate cover test

172 PD = prism diopters

173 \*Largest of distance or near

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11- Eye-related quality of life with diplopia

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**Table 2:** Comparison of PedEyeQ Scores Between Children Aged 12-17 Years with Diplopic Versus Non-Diplopic Strabismus.

	Diplopic Median (range) N=20	Non-diplopic Median (range) N=20	Mean Diff (95% CI)	P-value
<b>CHILD</b>				
Functional Vision	72 (25-95)	90 (45-100)	-15 (-26 to -3)	.008
Bothered by Eyes/Vision	65 (15-100)	90 (40-100)	-21 (-34 to -7)	.009
Social	85 (20-100)	90 (30-100)	-9 (-22 to 4)	.22
Frustration/Worry	53 (22-83)	75 (56-94)	-22 (-32 to -12)	<.001
<b>PROXY</b>				
Functional Vision	85 (15-100)	85 (60-100)	-5 (-17 to 6)	.54
Bothered by Eyes/Vision	80 (25-100)	90 (65-100)	-11 (-21 to 0)	.06
Social	88 (25-100)	97 (50-100)	-5 (-17 to 7)	.42
Frustration/Worry	81 (19-100)	78 (56-100)	-6 (-20 to 9)	.63
Eye care	92 (50-100)	92 (67-100)	-4 (-12 to 5)	.59
<b>PARENT</b>				
Impact on Parent and Family	95 (50-100)	95 (70-100)	-1 (-9- to 7)	.91
Worry about Child's Eye Condition	65 (15-95)	65 (10-100)	-8 (-23 to 6)	.42
Worry about Child's Self-Perception and Interactions	89 (36-100)	89 (43-100)	-3 (-16 to 10)	.89
Worry about Child's Functional Vision	75 (19-100)	75 (37-100)	-2 (-14 to 11)	.99

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