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Journal
Academic Pediatrics, 20(7)

ISSN
1876-2859

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Publication Date
2020-09-01

DOI
10.1016/j.acap.2020.01.001

Peer reviewed

HHS Public Access

Author manuscript

Acad Pediatr. Author manuscript; available in PMC 2021 September 01.

Published in final edited form as:

Acad Pediatr. 2020 ; 20(7): 910–916. doi:10.1016/j.acap.2020.01.001.

Receipt of Corrective Lenses and Academic Performance of Low-Income Students

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Abstract

Introduction: Untreated vision problems are associated with poor school performance. Whether providing glasses alone improves performance, however, remains unknown. We sought to test whether receiving glasses was associated with improved school performance for low-income minority students in Los Angeles.

Methods: From 2017–2018, we analyzed achievement marks in mathematics and language arts from 406 1st-5th grade students attending 24 public elementary schools who received glasses through a free school-based vision program between February-May 2014, and 23,393 of their non-participating same-school, same-grade peers. We calculated students' percentile rank during each grading period in the one year before and two years since they received glasses. Multilevel linear regressions tested whether percentile rank differed from baseline at each subsequent grading period. Models accounted for clustering at the school level and controlled for gender, grade level, and baseline class rank. Interaction terms tested whether associations differed by gender and class rank.

Results: Students increased 4.5 percentile points (p=0.02) in language arts in the second year after receiving glasses. There was no change in math achievement overall; however, those with

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Financial Disclosures: There are no financial disclosures to report by the authors of this paper.

baseline performance in the bottom tercile had an immediate and sustained improvement of 10–24 percentile points from baseline (interaction term p<0.001). Class rank for behavior marks decreased during the fourth grading period after receiving glasses but subsequently returned to baseline. There were no significant changes in work habits and no variation in results by gender.

Conclusions: Ensuring access to vision care may be a simple, scalable strategy to improve language arts performance for low-income minority children.

Keywords

school performance; vision care; school health

INTRODUCTION

Poor vision affects approximately 20% of school-aged children.[1] Although the majority of vision problems can be corrected with glasses, many children who need them do not have corrective lenses.[2] Low-income, minority children are disproportionately affected by uncorrected poor vision,[3] which may be due to financial, logistical, and systemic barriers to accessing vision care.[4] Hence, in a recent study of K-5th grade students in one urban center, more than 13% had an uncorrected visual deficit.[5]

Disparities in vision care may exacerbate disparities in academic outcomes.[1, 6] A variety of visual deficits are associated with reading problems;[7–9] lower grades in reading, writing and math;[10–12] and lower test scores in reading and math,[13, 14] though associations vary by child age and deficit.[15]. While it is logical that poor vision might negatively affect school performance, it is also possible that having an untreated vision problem might be a marker for poor access to vision care related to social determinants of health that also predispose to poor school performance.[16] Hence it is unknown the degree to which correcting vision with glasses alone can reduce disparities in school performance.[15] Although qualitative studies suggest receiving corrective lenses results in perceived improvements in school function,[2, 17] there are few U.S. studies examining whether providing glasses leads to quantitative improvements in academic performance[18] and none examining changes in grades or academic behaviors. Student grades are a key marker of school function that parents, teachers and school systems use throughout the school year to assess whether students are performing adequately,[19] and they are particularly important for early elementary school children who often do not participate in standardized testing.

Given the importance of academic achievement to a child's overall health trajectory,[20–22] understanding whether access to corrective lenses might improve school performance for low-income, minority school children is critical to calculating the return on investment for a large segment of pediatric vision care. Providing glasses to children with a correctable visual deficit might support their ability to function in the classroom and persist at academic tasks, ultimately leading to improved grades. Conversely, glasses alone may not be sufficient to overcome other powerful contextual factors that lead to poor academic performance; or students with untreated visual deficits may have already fallen too far behind to catch up academically. Finally, providing glasses to students might have psychological effects that could positively or negatively impact school performance, without remediation. To better

understand the relationship between receiving corrective lenses and school performance, this study examines whether effort and achievement grades of a sample of elementary school children from a large urban school district change, relative to their peers, after participating in a free school-based vision care program.

METHODS

Program Description

This is a secondary analysis of academic data for students from 24 public elementary schools who participated in Vision To Learn (VTL), a free, school-based vision program serving the Los Angeles Unified School District (LAUSD), and their same-school-same-grade peers who did not participate in the program. This study was reviewed and approved by the Institutional Review Boards of both our academic institution and the school district. At schools partnering with VTL, all students undergo an initial visual acuity screening by the school nurse. Parents of students who fail the screening or are observed by school staff to use corrective lenses receive a consent form for their child to participate in VTL. Children can also be referred to VTL by school personnel who suspect a vision problem based on their daily interactions with the student. Students returning a signed consent form receive a full eye exam by a pediatric optometrist at school, during the school day (See Appendix Table 1). Any child with a correctable visual deficit is fitted for glasses and invited to choose their frames. Alternative dates are offered to absent students. Approximately 2 weeks later, glasses are delivered in school and visual acuity with the new glasses is measured. There is no cost to families and no insurance information is requested. Parents also receive information about recommended vision care and how to obtain free replacement glasses, if needed. VTL has operated throughout the region since 2012, serving over 400 schools. They select schools based on their high proportion of students qualifying for free/reduced price meals and the willingness of the principal to participate.

Data Collection

For this study, schools served from February-May, 2014 were included. These dates were selected to ensure sufficient time to obtain follow-up academic data for two full school years after participants received glasses (i.e. through June 2016) and because VTL changed to a new electronic record keeping system in 2014 and could reliably access participant information during this timeframe. From VTL, a de-identified list of all participating students from each school was obtained with their date of service, gender, grade level, visual acuity before and after receiving glasses, and whether they already wore glasses at the time of service. VTL provided the school district with participating students' names, birthdates, and schools, which was used to link the VTL database to academic transcript data. Achievement marks in mathematics, language arts, work habits, and behavior were obtained for all three grading periods in the year prior to and for two years following the date students received glasses. This same academic data was obtained for participants' same-school-same-grade peers, who did not participate in VTL.

Statistical Analysis

Baseline comparisons of academic performance between VTL participants and peers were conducted using t-tests to compare sample means. The primary outcomes for the main analysis were the change in achievement grades for English Language Arts (ELA) and Mathematics, following receipt of glasses. LAUSD uses a 1–4 grading system for achievement scores (1 signifies not proficient; 2 is partially proficient; 3 is proficient; 4 is advanced). The work habits domain includes teacher assessments for whether a student makes good use of time, works independently, organizes materials, presents neat and careful work, and completes homework on time. Behavior assessments include whether a student follows directions and procedures, accepts and respects authority, cooperates well in a group situation, shows dependability, takes responsibility, exercises self-control, resolves conflicts appropriately, demonstrates appropriate interactions with peers, and demonstrates fair play. Students are given a 1–4 grade in each area (1 indicated limited progress; 2 indicates partial proficient progress; 3 indicates average progress; 4 indicates advanced progress). Because the grading scale changes in middle school, students who matriculated to middle school during the study period were excluded. Based on previous qualitative work, we hypothesized that both ELA and mathematics performance might improve after correcting poor vision.[17] Grades for achievement in each core competency in their domain were averaged together to create an overall ELA and overall math grade point average (GPA). A number of sensitivity analyses using the individual components of the math and ELA GPAs were conducted to ensure that our results were not sensitive to this decision. Details regarding the specific core content areas in each domain can be found at https://achieve.lausd.net/Page/13782. Similarly, an overall average GPA for work habits and behavior were created. To control for variation in grading across different environments,[19] each VTL student's grade-level class rank was calculated relative to their same-school-same-grade peers who did not participate in VTL. The use of class rank helps account for variability in teacher assessments across schools and grade levels and allows one to compare the academic growth of VTL participants against the growth of their non-participating peers.

To adjust for annual cyclical differences in how teachers assign grades, the median class rank over the 3 grading periods prior to when students received their glasses was used to calculate an individual baseline for each student. Multilevel linear mixed effects regression models were constructed to determine whether class rank significantly differed from baseline for each grading period after receiving glasses. Models accounted for clustering within schools and controlled for gender, grade level (1^{st} –3^{rd} vs.4^{th} –5^{th}) and baseline rank. As a secondary analysis interaction terms for gender by time, change in vision by time, and baseline class rank by time were included to test whether the impact of receiving glasses on academic achievement varied by these factors. To account for change in vision, the maximum change in visual acuity in either eye was calculated and then categorized into terciles (bottom, middle, and top tercile) because we hypothesized that there may be a non-linear relationship with the outcomes. Similarly, baseline student class rank was categorized by tercile (bottom, middle, top tercile). VTL provided both new and updated prescriptions. Because students already wearing glasses at baseline might be different from other participants, a sensitivity analysis excluding those already wearing glasses was conducted.

All the analyses were done using SAS 9.4 (Cary, NC) and P values <0.05 was considered statistically significant. Data analysis was conduction from March 2017-September 2018.

RESULTS

Our sample includes 406 students attending 24 elementary schools who were served by VTL, and 23,393 students who attended the same school in the same grade as a VTL participant at some point during the study period (Appendix Table 2). On average, schools served over 550 students, the vast majority of whom qualified for free/reduced price meals (89%) and were minority (76% Latino, 18% African American). Of the 406 VTL participants (Table 1), 46% were boys, 57% were in grades 1st-3rd at the time they were served. Twenty-eight percent already had glasses and experienced smaller changes in vision (Appendix Table 3). On average VTL students' baseline academic performance did not differ significantly from their peers (p>0.32).

Multilevel regression models were used to detect a change from baseline performance after participants were served, controlling for gender grade level, and baseline rank (Table 2, Figure 1). Results revealed no significant change in math achievement rank or work habits rank over the two years (6 grading periods) after receiving glasses. However, students demonstrated improved ELA achievement rank in the second year (5th and 6th grading periods) after receiving glasses of 5.07 (p=0.001) and 3.38 percentile points (p=0.03), respectively. For behavior, participating students had a decrease in behavior rank during the fourth grading period after they received their glasses of 3.9 percentile points (p=0.01) and then a return to baseline (grading periods 5 and 6).

As seen in Figure 2, when an interaction term for baseline class rank by time was included in the model, students who performed in the bottom tercile at baseline saw a large and sustained improvement in Math achievement rank following receipt of glasses (interaction term p<0.001), whereas those performing in middle and top terciles at baseline experienced reductions in performance rank over time, relative to their peers. To test for whether this finding simply represented "regression to the mean" over time, a sensitivity analysis was conducted replicating the same model with the 23,393same-grade-same-school peers who did not participate in the VTL program. There was not a significant interaction between baseline class rank and performance over time in this comparison group. Additionally, there was no significant interaction between baseline performance and rank over time for any other outcome. There also were no significant interactions by gender or change in vision. Finally, sensitivity analyses restricting the sample to the 193 students who remained in the same school throughout the study period and to the 294 participants not wearing glasses at baseline revealed similar results to our main analyses.

DISCUSSION

In this study, receiving glasses through a school-based vision care program was associated with improved class rank in ELA for all program participants in the second year after receiving glasses and improved Math class rank for participants who were performing in the bottom tercile prior to receiving their glasses. Interestingly, grade-level class rank for math

performance for those not in the bottom tercile at baseline declined after receiving glasses and there was a temporary decline in behavior grades after receiving glasses. These findings provide some evidence that correcting visual deficits alone might increase performance for low-income minority children with respect to reading and writing, which is a critical task of early elementary education. However, other aspects of school function likely require additional or different forms of support. Although the changes observed in class rank were modest, even small differences in relative rank are associated with long-term academic outcomes, as students are often grouped or tracked based on previous performance.[23–25] In addition, class rank may influence how students and adults see them and their expectations for the future, independent of absolute academic ability.[25] Further, academic performance, including grades and test scores, in early elementary school are associated with high school graduation,[26] which is linked to a host of positive health outcomes.[20, 27]

This study is unique in quantitatively testing whether school-based vision care improves grades among US elementary students. Prior to this work, two small randomized controlled trials from an Indian suburb[28] and rural school in China[29, 30] suggested that providing corrective lenses to school-aged children may improve test scores and classroom performance. In the United States, a study of 2nd and 3rd graders in Baltimore demonstrated improved reading skills for those given glasses, compared to those with normal vision, among students attending 12 schools participating in a reading support program.[31] Additionally, a recent study by Glewwe et al. of elementary schools in Florida,[18] demonstrated school-wide improvements in test scores for 5th and 6th graders attending schools that were randomized to participate in a vision-care program compared to students attending control schools. Similarly, they also found more consistent effects on reading versus math scores.

A significant lag time between receiving glasses and changes in ELA grades was observed. Based on prior qualitative work, teachers perceived students with uncorrected visual deficits were less likely to persist at academic tasks, which they felt inhibited their progress in reading, in particular, which requires individual practice.[17] Hence, it may take some time for students to establish positive habits and then to reap the benefits in improved reading and comprehension,[32, 33] and further, for those improved skills to be noted by teachers and reflected in a student's class rank. This hypothesis is supported by the overall pattern observed for this outcome whereby class rank was maintained at baseline for the first year after receiving glasses, followed by an increase in achievement.

In contrast, math achievement improved immediately, but only for those initially performing in the bottom tercile. In qualitative focus groups, teachers reported students with poor vision had difficulty following class lessons but that classroom attention and participation improved after students received glasses.[17] The authors speculate that classroom instruction and participation might play a particularly important role in mathematics performance;[34] hence it's possible an improvement in vision allowed for a more immediate improvement in math performance, but this only for those having particular difficulty keeping up with the class.

Finally, a steady decline in behavior grades after receiving glasses was observed, followed by recovery. While this study cannot determine the reason for this pattern, it is possible that

participating students experienced some level of stigma following receipt of their glasses that negatively impacted peer interactions, and that this effect wore off over time either as they developed coping mechanisms, as they or their peers became accustomed to the glasses, or as participants stopped wearing them. It is possible that a similar phenomenon explains why students initially performing at or above average in mathematics also experienced a decline in performance after receiving glasses. Although social stigma related to wearing glasses appears variable,[35] qualitative discussions with low-income minority populations, such as this one, suggest it remains a concern and can impact both bullying and self-esteem.[17, 36]

Alternatively, VTL participation may be a marker for other social and economic risk factors that are associated with poor school function over time. VTL participants had a visual deficit that was completely or partially uncorrected prior to participating in the program. The presence of an unmet vision need may signify these students come from families facing barriers to healthcare access (such as poverty or lower health literacy) that also correlate with lower academic achievement. That these factors might be partially mitigated by providing access to corrective lenses further reinforces the need to ensure all children, but especially those facing other barriers to school performance and healthcare access, receive regular and timely vision care.

Limitations

This study is limited by its observational study design, which makes it impossible to determine whether VTL participation caused improved school performance. It is possible that some other factor resulted in the outcomes changes or that teacher grading practices were influenced by simply observing students wearing their glasses. The analysis is also limited by the data available and, although the use of class rank rather than grades could account for school-level differences in grading practices, we could not account for potential classroom-level. It is also unknown how results might change with respect to other educational outcomes, such as test scores. Although program participants received glasses, it is unknown how many actually wore them, nor what the specific visual deficit was. It is possible that accommodative problems, for example, might have a greater impact on school function than problems with distance vision. How long the visual deficit existed prior to program participation is also unknown. As noted above, there are likely unmeasured differences between program participants and non-participants, and participating schools may not be representative of the district or region. Although nearly all students attending study schools are low-income and minority, as is consistent with district demographics, those with uncorrected visual deficits might be facing additional challenges. It is also possible that students who failed the initial school-wide vision screen but who chose not to participate in VTL, sought vision care elsewhere. A sizeable portion of participating students already wore glasses (28%), although this is similar to other free vision-care programs[37] and sensitivity analyses excluding these students yielded similar results. Finally, Glewwe et al. found evidence that school-based vision care may have school-wide impacts—or a spillover effect—whereby students with normal vision benefit academically from their peers receiving vision care.[18] Together, these factors likely bias our results towards the null, potentially underestimating the true effect size of correcting vision on school performance. Given that

our results are from a single, large, urban school district serving primarily low-income Latino children, our results may not generalize to other populations. However, this represents an important group to study that is at increased risk for uncorrected vision and poor academic outcomes. We also investigated multiple outcomes, which, though correlated, may increase the chances of committing a type I error. Finally, it remains unknown how our findings might change or fade out over a longer period.

CONCLUSIONS

Despite these limitations, our findings indicate that ensuring all children have access to vision care may be one effective tool to address academic and vision disparities. The associations between vision care and school performance may be complex and varied, depending on the specific academic outcomes and student characteristics. Future studies might better examine potential differences by visual impairment diagnosis, age or grade-level, socio-demographics and more detailed measures of school performance or test scores. Better understanding these factors is important for identifying specific subpopulations for whom access to vision care might be particularly critical to their academic success. Given that education is both a powerful social determinant of health[27] and a nearly ubiquitous aspect of childhood, small individual improvements in academic performance may have large impacts on population health over time. Hence, investing in pediatric vision care may have both academic and health returns beyond the immediate benefits to visual functioning.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

ACKNOWLEDGMENTS

This work was supported by Vision To Learn, the NIH/National Center for Advancing Translational Sciences [grant number UL1TR000124]; and the UCLA Children's Discovery and Innovation Institute. The funders played no role in the study design, analysis, or presentation. The authors have no other conflicts of interest or financial relationships relevant to this article to disclose. Dr. Dudovitz conceptualized and designed the study, led the interpretation of the analysis, drafted the initial manuscript, and reviewed and revised the manuscript. Drs. Sim and Elashoff assisted in study design, conducted the data analysis, assisted in interpretation of the analysis and reviewed and revised the manuscript. Dr. Klarin assisted in data collection and interpretation of the analysis and reviewed and revised the manuscript. Dr. Slusser assisted in study design, interpretation of the results, and reviewed and revised the manuscript. Dr. Chung conceptualized and designed the study, interpreted the analysis, and reviewed and revised the manuscript.

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What's New:

Poor vision is associated with poor school performance but it is unknown whether providing glasses improves school performance. We found that language arts class rank improved the second year after receiving glasses. Mathematics class rank improved only for low-performing students.

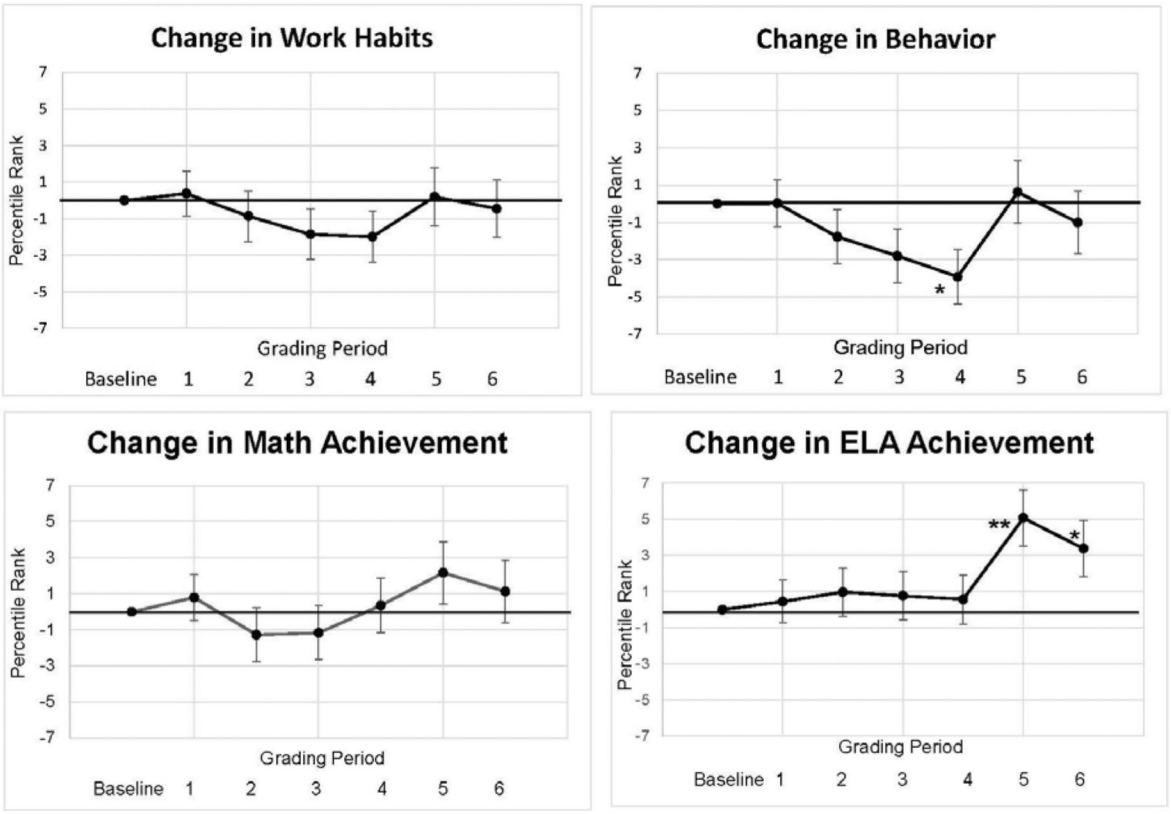

Figure 1. Change in Class Rank Following Receipt of Glasses

Percentile rank was estimated using multilevel linear mixed effects regression models to determine whether class percentile rank at each grading period after receiving glasses was significantly different from baseline. Models accounted for clustering at the school level and controlled for gender, grade level, and baseline class rank. ELA= English Language Arts. Point estimates and standard errors are presented. *=p<.05, **=p<.01, ***=p<.001. For the Math and ELA outcomes N=406, for Work Habits N=403, and for Behavior N=404.

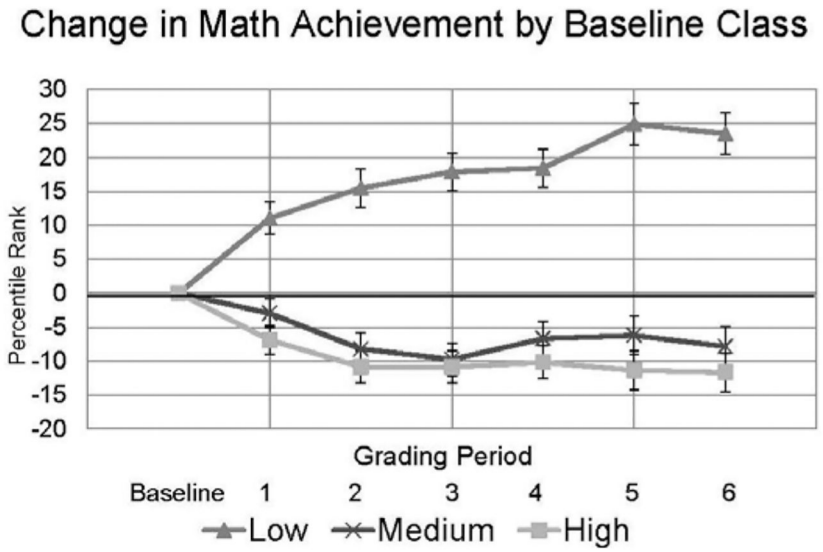

Figure 2. Change in Math Achievement Class Rank Following Receipt of Glasses, by Baseline Performance Tercile

Percentile ranks was estimated using multilevel linear mixed effects regression models to determine whether class percentile rank at each grading period after receiving glasses was significantly different from baseline. Models included interaction terms of baseline class rank by time, accounted for clustering at the school level, and controlled for gender, grade level, and baseline class rank. Point estimates for those with low, medium and high baseline performance and standard errors are presented. N=406.

Table 1.

Participant Characteristics

	VTL Sample (N=406) N (%)		
1st–3rd Grade	232 (57.1%)		
4th–5th Grade	174 (42.9%)		
Male	185 (45.6%)		
Already had glasses	112 (27.6%)		
Baseline Academic Performance	**VTL Sample N=406**	**Peers N=23,393**	**P-value**
	Mean (std. dev)	**Mean (std. dev)**	
ELA	2.66 (0.57)	2.7 (0.56)	0.53
Math	2.57 (0.76)	2.64 (0.71)	0.32
Work Habits	2.92 (0.65)	2.93 (0.63)	0.79
Behavior	3.12 (0.63)	3.08 (0.6)	0.59

P-value determined via t-test. ELA=English Language Arts. VTL sample represents those served by VTL from February-May of 2015 and their peers are all students attending the same school and in the same grade as VTL participants but who did not participate in the program.

Table 2.

Estimated Change in Class Rank Following Receipt of Glasses

Effect	Comparison	Math (N=406)	ELA (N=406)	Work Habits (N=403)	Behavior (N=404)
Grading Period	**1 vs Baseline**	0.79 (1.29)	0.45 (1.18)	0.38 (1.21)	0.02 (1.26)
	2 vs Baseline	−1.27 (1.49)	0.97 (1.35)	−0.85 (1.38)	−1.77 (1.45)
	3 vs Baseline	−1.16 (1.49)	0.77 (1.35)	−1.85 (1.38)	−2.8 (1.45)
	4 vs Baseline	0.35 (1.50)	0.57 (1.35)	−1.97 (1.39)	**−3.92 (1.46)** **
	5 vs Baseline	2.16 (1.73)	**5.07 (1.54)** **	0.20 (1.58)	0.62 (1.67)
	6 vs Baseline	1.13 (1.73)	**3.38 (1.54)** *	−0.45 (1.58)	−1.01 (1.67)
Base Rank	**High vs Low**	**−26.27(2.49)** ***	**−26.3(2.39)** ***	**−26.11(2.49)** ***	**−27.94(2.49)** ***
	Med vs Low	**−22.93(2.49)** ***	**−15.22(2.39)** ***	**−14.76(2.42)** ***	**−19.34(2.46)** ***
Gender	**Female vs Male**	**4.96 (2.00)** *	**5.07(1.92)** **	**7.50(2.03)** ***	**4.81(2.02)** *
Service Grade	**1st–3rd vs 4th–5th**	**−5.27(2.14)** *	−3.29(2.02)	−0.03(2.04)	1.56(2.09)

Model presents estimated change in class rank and standard errors in parenthesis for each outcome. ELA= English Language Arts.

* =p<0.05,

** =p<0.01,

*** =p<.001.

[Note: Boldface indicates statistical significance (p<0.05).]