Focusing on the Future: Strategies to Combat Childhood Myopia
Team Number 4: Tim Leong, Michelle Liu, Shruti Jain, Tejasvi Kalakota
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Overview

The global prevalence of screen exposure is on the rise, with computer devices now an integral part of our daily lives. It's reported that the average American spends 7 hours a day looking at a screen[1], a figure only expected to grow. Projections indicate that by 2050, nearly half of the world's population will be affected by nearsightedness[2]. This escalating trend raises significant concerns, particularly with children whose eyes are still developing and are more susceptible to the strains of prolonged screen usage.

Our research aims to identify practical recommendations for parents to mitigate the risk of myopia in their children. Since it's impossible to completely eliminate screen exposure, our objective is to identify strategies that parents can teach their children and reduce their likelihood of developing myopia.

Intended Audience

Our intended audience are parents with young children who are concerned with how screen time affects their children's eyes.

Existing Literature

- One study in China analyzed the impact of the pandemic on myopic shift from 2015 - 2020. They wanted to understand how reduced outdoor activities and increased home confinement affected children from age 6 - 8. They found that home confinement was associated with significant myopic shift[3].
- A systematic review and meta-analysis of 44 articles sought to understand the effect of digital smart devices, defined as smartphones and tablet computers, on myopia. While the findings were mixed, the researchers found that smart device screen time alone or in combination with computer use had a significant association with myopia. Their interpretation of the articles reviewed suggested that smart device exposure may be associated with an increased risk of myopia[4].
- A study sought to understand the efficacy of the 20/20/20 rule. The rule, first proposed in the 1990s, suggested that patients take a 20 second break every 20 minutes to look at something 20 feet around while using digital devices. They found limited evidence supporting the specific numbers composing the rule[5].
- A topical review aimed to assess the effects of various types of measures on myopia. The review included spending more time outdoors, optical interventions such as the bifocal/progressive spectacle lenses, soft bifocal/multifocal/extended depth of focus/orthokeratology contact lenses, refractive surgery, and pharmacological treatments and found varying degrees of efficacy for the various interventions[6].

Anticipated Impact

Enable parents to make informed decisions regarding screen exposure to reduce myopia onset and myopic progression among children.

Main Research Question

The main focus of our study is to determine the following:

- Are there specific screen time exposure techniques that help reduce the risk of myopia in children?

Sub Research Questions

To help us answer that question, we've designed a series of sub questions that will enable us to evaluate various techniques and approaches to reducing myopia risk.

1. What is the optimal time to rest your eyes from looking at a screen to reduce myopia progression?
2. What is the optimal distance to view your device from?
3. What's the best kind of ambient lighting to reduce stress on the eye?
4. What are the optimal display settings to set on your device?

Definitions

- **Myopia:** Also known as nearsightedness, is a visual condition where objects that are close appear clear, while objects that are farther away appear blurry.
- **Myopic onset:** When an individual's diopters measure less than 0. At this threshold, individuals are diagnosed with myopia.
- **Dioptre:** The unit of measurement for eye prescriptions that measures the focusing strength of a pair of contacts or glasses.
- **Myopia progression:** An increase with time in the negative sphere dioptric power necessary for correction to best visual acuity.
- **Progressive myopia:** Nearsightedness that worsens over time.
- **Screen exposure:** The time spent looking at computer screens.
- **Children:** Youth aged from 8-10.
- **Device settings:** The adjustable tone, brightness, and mode that are customizable on a device. The mode refers to the light and dark colored themes.
- **Axial Length**: Measurement of the length of the eye serves as a critical outcome measure, reflecting eye growth and myopia progression.
- **Refractive Error**: Measurement of the degree of nearsightedness is another essential outcome measure.
- **F.lux:** A software program that automatically adjusts the tone and brightness of the screen based on the time of day.

Study Design

For this study, we will use an experimental design to observe and compare groups that naturally differ in their exposure to specific screen time techniques, and implement interventions with random assignment. Our selected participants will be a sample of children aged 8-10 within the Bay Area with diverse demographics, which will enhance the generalizability of our findings.

To determine eligibility, we'll have each potential participant's parents fill out a questionnaire. The questionnaire will screen for preexisting conditions that may predispose the candidate to higher myopia risk, whether the parents already enforce screen time rules, and whether they have a proper ergonomic workspace setup in place for their children.

From the eligible candidates, we'll be selecting a group of 1,000 children ages 8-10 to participate in the study. Those children will be randomly split up into 4 groups, 250 for each experiment. Each of the groups will be further divided into control and test groups with an even split between the two groups.

We will conduct a series of four experiments over the course of two years. Each experiment will involve a control and a test group so we can evaluate the effectiveness of the treatment. The experiments will use a **mixed method** approach and we'll collect data in 3 different ways. Data will be collected quarterly. Each participant will receive a routine eye exam, we'll collect data from their device, and the parents will fill out a questionnaire.

- Parents will complete questionnaires throughout the life of the experiment to help us understand children's behaviors and habits.
- The participants will be instructed to visit their optometrist once a quarter for monitoring and evaluation. This data will help inform the health of the participant's eyes throughout the study.
- We'll collect data from each participant's phone strictly related to screen time, display settings, and eye tracking to determine whether they adhered to the guidelines of the experiment.

Participants in the control group will be instructed to maintain their routines and habits without any change. Subjects in each of the test groups will be instructed to follow specific instructions regarding their screen usage.

For each specific experiment, the guidelines will be as follows:

- Experiment #1: What is the optimal time to rest your eyes from looking at a screen to reduce myopia progression?
    - Participants in this test group will be instructed to take a 1 minute break to rest their eyes during prolonged screen use, which we define as an hour or more. A notification will pop up on their device and remain there until the minute is up. We'll be using the camera built into their device to gauge whether or not the subject adhered to the break.
- Experiment #2: How far away should you be from your device when using it? / What is the optimal distance to view your device from?
    - Parents of participants in this test group will be instructed to create a proper ergonomic workspace setup for their children. iOS 17 introduced a software update that enabled screen distance tracking (Apple Support Docs). For iOS devices, we will use this to measure screen distance. On Android and Windows devices we will use Posture Minder to measure the distance.
- Experiment #3: What's the best kind of ambient lighting to reduce stress on the eye?
    - Participants in this test group will be instructed to use their devices in a well-lit room when indoors. We define well-lit conditions as evenly distributed throughout the room (natural or artificial light) and where there are no harsh glares/reflections present on the screen. For artificial lighting, we'll provide the participants with warm white bulbs for their light fixtures.
- Experiment #4: What are the optimal display settings to set on your device?

- For participants in this test group, we will set their screen settings on all of their devices to “Dark Mode”, increase the warmth of the colors on the screen, and enable f.lux which automatically adjusts the color settings based on the time of day to reduce eye strain.

Variables

In this study, the primary focus is understanding the relationship between screen time exposure techniques and the risk of myopia in children. The key concepts revolve around the interventions implemented to mitigate myopia risk during screen time and how these interventions influence myopia outcomes in children.

- Independent Variables: This variable represents the intervention itself—the specific techniques employed during screen time. It allows the study to explore whether certain strategies have a measurable impact on myopia risk in children.
  - Experiment #1: Eye rest duration of 1 minute after prolonged usage of a device
  - Experiment #2: Viewing distance from the specific devices
  - Experiment #3: Ambient lighting conditions
  - Experiment #4: Optimized display settings
- Dependent Variables: These variables serve as key outcome measures. They allow the study to quantify the presence or absence of myopia and the degree of myopia progression.
  - Myopia onset and progression, assessed through child’s medical records.
- Control Variables: Control variables help isolate the effects of screen time exposure techniques by accounting for potential confounding factors.
  - Baseline myopia, genetic factors, age and gender of participants
- Potential Confounding Variables: Identifying and controlling for confounding variables is crucial to ensure that observed effects are not due to the influence of these extraneous factors.
  - Outdoor time, socioeconomic status, and educational activities.
- Outcome Measures: These measures provide objective indicators of myopia outcomes.
  - Axial length, refractive error
- Post-Experiment Analysis Variables:
  - Post-experiment analysis will involve more complex statistical methods to enhance the robustness of the findings. Possible variables for analysis may include:
    - Demographic Characteristics: Controlling for demographic variables, such as age, gender, and socioeconomic status, in statistical analyses to account for potential confounding factors.
    - Adherence Level: Analyzing the degree to which participants adhere to recommended screen time exposure techniques can contribute to understanding the effectiveness of the interventions.

Data

Our collected data can broadly fall into the respective categories:

1. Surveys/Questionnaires:
   a. Providing parents of the participants with series of questions to answer which include:
      i. **Socio-demographic information:** Individuals in certain socio-economic groups are less likely to receive regular eye checkups and have limited healthcare access,

it is important for us to understand this information so that we can better assess the results of our study

ii. **Existing screen time habits:** Will helps us better understand both our control and test group and the stressors their eyes have experienced beforehand

iii. **Pre existing conditions:** Risk of Myopia has been documented to be associated with other medical conditions, and it is important to make note of this when assessing the results of our study, and may even provide important markers about participants to potentially exclude in the study

iv. **Comprehensive genetic history:** which includes information about: Family members who suffer from Myopia (ie Please list out the child's relationships with individuals who have Myopia and discuss the nature of the relationship with child); Sample response: Child A's Uncle Craig has nearsightedness. This helps us refine the context of each subject when analyzing the data because people with a family member with Myopia are at greater risk of inheriting the disorder. Additionally, we will ask about family relationships with individuals who suffer from other degenerative eye conditions . This provides more context about symptoms that the subject in the study is experiencing .

v. **Parental input about the history of child eye health:** (note this information is not the sole information for how we will be evaluating the child's myopic status and is instead a supplemental tool for us to better understand the Medical Records of the child). This includes: Current or former diagnosis of Myopia and other medical conditions or Progression of Myopia overtime if the child has it

2. Device Metrics Based Data
    a. This is frequently founds in the settings and account section of most currently used devices
    b. Specific Metrics we will be collecting include:
        i. Screen Time (the measure of the time may vary from device to deceive but we will ensure that the collected time units are all converted to minutes), we should assess screen time as both total overall screen time and also divide it into specific sections because the screetime may vary depending on the day or time of day.
        ii. Distance from Phone: In phone this is turned on via setting for windows we must using the following application: Postureminders
        iii. Device Display settings [most useful for experiment 4]
            1. Brightness Levels vices the participant can use because the brightness spectrum various across different versions iphones let alone androids) We want to standardize the scale for "brightness"
                a. However the goal is evaluate the spectrum of the brightness the child
            2. Color Temperature/Light|Dark Mode Activation Settings
                a. This factor is important because blue light exposure at night time has been documented to disrupt melatonin production in the body, and overall well-being in young adults. Therefore, it is important to understand if this factor can also affect eye health.

    b. Once again this factor may need to be standardized across participants
3. Medical Administration Records (MARs)/Electronic Health Records(EHRs)
    a. With the consent of the parent we can extract information about the child's diagnosis, lab records, and anatomical information related to patients health
    b. MARs and EHRs are to be looked at in context with the information the parent provides about the child's conditions (clinical providers have more objective and informed informations about the status of a child's eye conditions or preexisting conditions, and this should be primary and serves)

Sample

From the eligible candidates, we'll be selecting a random sample of 1,000 children ages 8-10 to participate in the study. Those children will be randomly split up into 4 groups, 250 for each experiment. Each of the groups will be further divided into control and test groups with an even split between the two groups. Consent will be sought from parents or legal guardians of eligible children within these schools.

Hypotheses

Children who follow the specified eye-resting schedule, viewing distance, ambient lighting conditions, and optimized display settings in their respective experiment groups will demonstrate a reduced risk of myopic onset and progression as compared to children in the control groups.

- Experiment #1:
    - Null Hypothesis: There is no significant difference in myopia onset and progression between children who follow the specified eye-resting schedule during screen time exposure and those who do not.
    - Alternative Hypothesis: Children who follow the specified eye-resting schedule during screen time exposure will show a reduced risk of myopic onset and progression as compared to children in the control groups.
- Experiment #2:
    - Null Hypothesis: There is no significant difference in myopia onset and progression between children who follow the specified viewing distance during screen time exposure and those who do not.
    - Alternative Hypothesis: Children who follow the specified viewing distance schedule during screen time exposure will show a reduced risk of myopic onset and progression as compared to children in the control groups.
- Experiment #3:
    - Null Hypothesis: There is no significant difference in myopia onset and progression between children who follow the specified ambient lighting conditions during screen time exposure and those who do not.
    - Alternative Hypothesis: Children who follow the specified ambient lighting conditions during screen time exposure will show a reduced risk of myopic onset and progression as compared to children in the control groups.
- Experiment #4:

- Null Hypothesis: There is no significant difference in myopia onset and progression between children who follow the optimized display settings during screen time exposure and those who do not.
- Alternative Hypothesis: Children who follow the optimized display settings during screen time exposure will show a reduced risk of myopic onset and progression as compared to children in the control groups.

Statistical Methods

The statistical analysis for this study will involve a combination of descriptive and inferential methods to assess the relationship between screen time exposure techniques and the risk of myopia in children. Here's a broad overview of the statistical methods we plan on using.

Comparative Analysis / Significance Testing : Employ comparative analyses to assess differences in myopia outcomes between groups exposed to different screen time techniques. This may involve t-tests, chi-square tests, or other appropriate methods based on the nature of the variables. Significance Testing will be applied within the comparative analysis to determine if the observed differences are statistically significant A predetermined level of significance (e.g., $p < 0.05$) will be set to interpret the results.

Regression Analysis: Perform regression analyses to investigate the impact of screen time exposure techniques on myopia outcomes while controlling for relevant covariates and moderating variables. Multiple regression may be used to account for the influence of several predictors simultaneously.

Post-Experiment Analysis: In post-experiment analysis, use more advanced statistical techniques, such as analysis of covariance, to control for demographic characteristics and other potential confounding factors.

Potential Risks

1. HIPAA and medical privacy concerns
    a. Extracting medical data needs to be done very carefully, and even when done carefully there are issues that may arise regarding medical leakage. We will do our best to mitigate this risk by enforcing strict guidelines on data access and anonymization.
    b. We will also provide all researchers working on this project with training regarding handling health care data
2. Compliance Issues
    a. Parents may feel uncomfortable continuously enforcing screen use techniques of their children, and may even diverge from the responsibility
    b. Children may also be in refusal when it comes to participating with the rules and guidelines of the experiment
    c. Meeting with parents on a regular basis and developing an open line of communication between the child, parents, and researchers
3. Validity of the questionnaire data
    a. Important to recognize the limitations and biases of parental reporting of child's health and overall status information
    b. We are focusing on reducing this with cross-validation of the parental reporting with information from the participants MARs

4. Parental Expectations
    a. Parents may pull their children out of the study because they may feel the experiment is not “useful" or not yielding the insights they had anticipated. While many parents, educators, and participants, may have misaligned perspectives about the results and potential impact of the study, it is important to be transparent from the start about how this analysis and experiment in results will yield results not entirely in line with our expectation. It is exploratory in nature.

Deliverables

The final deliverable of the study will be an article published in a variety of news publications in their health section. This will ensure that our intended audience is reached. Prior to that, we’ll publish a peer-reviewed publication summarizing the research question, methodology, results, and conclusions. The deliverables aim to contribute valuable insights into the relationship between screen time exposure techniques and the risk of myopia in children, informing future research and potential interventions in this domain.

Anticipated Timeline

- Months 1 - 2: Project Planning and Design
- Months 3 - 6: Participant Recruitment and Baseline Assessment
- Months 7 - 12: Implementation of Screen Time Exposure Techniques
- Months 13 - 18: Data Collection
- Months 19 - 22: Data Analysis
- Months 23 - 24: Advanced Statistical Analyses
- Months 25 - 27: Interpretation and Reporting
- Months 28 - 30: Peer Review and Revisions
- Month 31: Final Deliverable

Statements of Contribution

Michelle Liu
I contributed to the original proposal for the Overview, Research Questions, and Study Design sections. For the final proposal I contributed to the study design and variables sections, as well as completed the statistical methods and deliverables portions of the proposal. Our group had a lot of great discussions to refine our study, but it took some time to focus on an appropriate research question which led to some delays. For next time, I now realize the importance of establishing a strong, clear, novel research question before digging into the details of the proposal.

Shruti Jain
I contributed to the study design section of the original proposal. For the final proposal I contributed to the revamping of the research questions along with the completion of the study design, variables and hypotheses sections of the report. The group was communicative and collaborative in the efforts to take in and discuss each other's and the professor's feedback. The discussions were well run and everyone was open minded, bringing to the table a slew of perspectives. Next time, we should start off by discussing all aspects of the proposal first before designating different sections right off the bat. This would limit the back and forth and rewriting of sections.

Tejasvi Kalakota
I contributed to the data section of the original proposal. For the final proposal I also contributed to the data sections and Potential Risks. Our group has had several collaborative discussions via zoom and slack. The group exhibited adept communication and collaboration throughout this project. Our discussions were efficiently conducted with a receptiveness to diverse viewpoints. To improve in the future I suggest that we commence by comprehensively addressing all the guidelines of the proposal before allocating specific sections. This approach would have helped us prevent unnecessary revisions and streamline the workflow.

Timothy Leong:
For the original proposal, I facilitated discussions around what research question we should focus on and identified how we could best split up the work. I completed the section and research questions section and made sure that everyone was aligned on our initial proposal and submitted the assignment. For the final project, I continued to help manage the project. For the document itself, I revised the overview section and contributed to our study design section in light of our adjusted research question. I developed the slides for the overview and study design section as well. Next time, we could spend more time thinking about how we'd design the research around the question to make sure we had the right question.

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