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LITERATURE REVIEW

PEEK Acuity and its Potential to Improve Visual Acuity Screening

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Abstract

Introduction: Uncorrected refractive errors contribute to 43% of the leading causes of global visual impairment. Early screening is essential to detect visual impairment and to plan early intervention. Portable eye examination kit (PEEK) Acuity has the potential to help improve early detection; however, its validation needs to be studied. **Purpose:** To carry out a validation test of PEEK Acuity as a visual acuity examination tool compared to the Snellen Chart. **Reviews:** PEEK Acuity is a smartphone-based screening modality that can be used offline and has a low false positive rate. Several studies have been conducted to evaluate the accuracy of using the PEEK Acuity application. The duration of examination using PEEK Acuity is also said to be significantly shorter than that of using Snellen Chart in preschool-age children. **Conclusions:** The PEEK Acuity application can currently be considered a viable alternative for vision screening, especially for widespread screening in both the community and school-aged children who require a high level of specificity to avoid errors in identifying cases.

Keywords: visual acuity; screening; Snellen; PEEK Acuity

Introduction

Globally, the leading causes of visual impairment were uncorrected refractive errors (myopia, hyperopia, or astigmatism). Data from the World Health Organization (WHO)[1] shows that approximately 2.2 billion people globally have vision impairment, a significant portion affecting children. Recent data[1] indicates that 448 million children and adolescents have refractive errors, while 90 million children and adolescents live with sight loss. Refractive errors continue to dominate this impairment, especially in populations from developing countries. In Indonesia, more recent surveys conducted between 2014 and 2016 showed that blindness was approximately 3.0%, with uncorrected refractive errors being one of the major contributing causes of visual impairment.[2] The COVID-19 pandemic exaggerated children's interaction with electronic devices, resulting in an increase in screen time, which played a significant role in increasing the prevalence of refractive disorders in children. Ma et al.[3] found that myopia progression increased from -0.3 ± 0.5 D to -0.6 D during the COVID-19 pandemic.[4]

Health screening is a health examination procedure that is carried out to detect early health problems that can interfere with a 'child's learning, growth, and development process so intervention can be taken immediately. Timely and regular screening is essential to detect visual impairment and its etiology. Poor visual acuity has been shown to contribute to decreased school performance and social or emotional problems.[5]

The Snellen chart is one of the most commonly used charts for measuring visual acuity. This method has limitations, such as inconsistent changes in letter size on each row. Several mobile-based applications have been developed to measure visual acuity via smartphone. One of the popular mobile-based applications for measuring visual acuity is early treatment diabetic retinopathy study (ETDRS) based portable eye examination kit (PEEK) visual acuity, which is currently more standard than the Snellen chart. However, it is necessary to validate the

PEEK Acuity application before it is used generally.[6] This review aims to compare the usage of PEEK Acuity as an alternative to the Snellen chart in visual acuity screening.

Reviews

Refractive error is a clinical condition that occurs when the eye fails to focus light rays from an object onto the macula of the retina, resulting in blurry images. Refractive disorders affect human life, both children and adults, causing difficulty in carrying out routine tasks.[7] The high prevalence of significant refractive errors and the costs associated with their correction pose a significant public health and economic problem.[7] Refractive errors can be divided into myopia, hyperopia, and astigmatism. Visual impairment resulting from uncorrected refractive errors can have immediate and long-term consequences for children and adults, such as loss of opportunities to receive education and work, loss of economic benefits for individuals, families, and communities, and impaired quality of life.[8]

Myopia or hyperopia causes distant objects to become blurry. Presbyopia causes close objects to become blurry. Astigmatism causes objects to appear stretched or blurry. Other symptoms may include double vision, headaches, and eye strain. Hyperopia can occur in the neonatal period. The eye axis is too short, however, the eyeball changes to emmetropia after the neonatal period. Myopia occurs when the eyeball grows excessively, where the axial length of the eyeball becomes too long. Myopia is the most common and important public health problem due to its increasing incidence and high risk of serious eye complications. Although preventable and curable, uncorrected or under-corrected myopia is a major cause of visual impairment and a significant risk factor for blindness.[9],[10]

The prevalence of refractive errors and myopia varies across geographic regions and different ethnicities living together in the exact geographic location. It indicates a strong environmental influence and genetic predisposition. The prevalence of myopia in the United States has increased from 25% to 44% between 1972 and 2004.[4],[5],[11] It is estimated that 4.8 billion people, which compose half of the 'world's population, will be affected by myopia by 2050.[4],[5],[11] The economic burden of eye disease is only approximately USD 139 billion in the United States, with nearly USD 16 billion spent on myopia correction alone.[4],[5],[11]

Implementing cost-effective and feasible screening techniques in low-income settings is needed to detect uncorrected refractive errors and improve subject education. Assessment of the eye's refractive status is divided into objective and subjective refraction. Subjective refraction is an assessment of refractive status using spherical and cylindrical lenses to determine the best corrected visual acuity. Various instruments used for subjective refraction assessment include a manual refraction unit with a phoropter, trial frame, trial lens, Snellen chart, pinhole, eye patch, duo chrome test, and Jackson's cross cylinder.[12],[13]

Without access to screening, undetected and untreated visual abnormalities in children can lead to permanent vision loss (amblyopia) and hinder study progress in school.[14],[15],[16] Amblyopia is decreased vision due to abnormal visual cortex development in infancy or childhood. Screening and management of this condition requires reliable visual acuity assessment methods. Visual acuity testing should cover all critical parameters and methods necessary to assess amblyopia accurately. Visual acuity is the most frequently measured visual function in clinical practice.[14],[15],[16] Visual acuity measurements establish the need for clinical investigation and measure changes in central vision over time. Visual acuity is perhaps the best-known and most important measure of visual function.[14],[15],[16]

Tests for visual acuity using the Snellen chart are the most common evaluation of visual acuity in primary care offices in the United States.[17] Paper graphs with various optotypes (Lea drawing, tumbling "E" Snellen chart) have been used to assess distance visual acuity. These charts developed in the 1860s had several design flaws, such as non-geometric progression of letter sizes and variable numbers of letters used per row (one letter at the top of the chart and more than five letters on a 20/20 row).[17] Different letters or optotypes with standard symbols for vision testing have varying readability at the same size, and secondary effects such as crowding are known to affect the 'patient's ability to determine the optotype correctly. They can, therefore, lead to measurement bias.[17]

PEEK is a smartphone-based screening modality that is accessible in low-income areas and has a low false positive referral rate. This free downloadable app has been shown to have 85-90.1% sensitivity and 97.5-98% specificity when used to test visual acuity by community members in the patient's home compared to ETDRS logMAR charts. PEEK Acuity aims to bring visual acuity screening to a population with great potential in school-based screening programs. PEEK Acuity uses a tumbling "E" system with a crowding bar that can be administered to nonverbal patients.[18],[19]

Bastawrous et al.[18], explain that PEEK Acuity only uses the letter "E" in four orientations. The examinee points in the direction of arm E, and the examiner records the answer by swiping the screen in the same direction. It helps prevent subliminal cues from being sent to the examinee, and the examiner is not responsible for determining when testing is completed or how

scoring is conducted. The application will automatically adjust screen brightness according to the surrounding environment for accurate measurements. PEEK Acuity offers standard alternatives to "finger counting," "hand movements," and "light perception." The application will display one to four bars to replace count fingers. A solid black square, half the screen's width, moves back and forth across the screen for hand movement.[6],[18] For light perception, PEEK Acuity turned on the phone's light emitting diode (LED) flashlight, and subjects were asked to identify whether and when they saw the light turn on and off. Completion of the test is indicated by sound and vibration alerts.[6],[18]]

Discussion

Visual acuity is one of the important parameters in evaluating visual function. Visual acuity measurements can be made quickly and affordably with various commercially available charts, printed online and increasingly available for mobile devices. Around 2,2 billion people worldwide experience vision impairment, half of which is preventable, showing the importance of access to adequate eye health services, especially in rural areas of developing countries.[3],[12] In addition, there is a shortage of eye health workers in developing countries, where the ratio between the number of ophthalmologists and the population is much lower compared to developed countries, especially in urban areas.[3],[12]

In this globalization era, telemedicine has significantly benefited various medical conditions, including eye health. Reliable measurement of visual acuity remains a significant concern for ophthalmologists. Therefore, several mobile-based applications have been developed to measure visual acuity via smartphone, providing an effective way to evaluate visual acuity, especially in remote areas of low-middle-income countries. One such application is PEEK Acuity, an application developed by PEEK Vision Ltd from England that is available for Android.[17],[20],[21]

One of the main advantages of PEEK Acuity is its ability to provide an accurate and easily accessible visual acuity test without additional equipment. This application is also free, so anyone at any time can access it. PEEK Acuity is a practical and efficient choice for individuals who want to carry out visual acuity tests[18],[19] independently.

Several studies have evaluated the accuracy of the PEEK Acuity application in measuring visual acuity. Satgunam et al.[22] found no significant difference in distance visual acuity between PEEK Acuity and COMPlog. Meanwhile, Zhao et al.[23] noted that the ICC for visual acuity scores measured using the PEEK Acuity application and standard clinical examination methods was 0.85 for the second eye. Research conducted by de Venecia et al.[24] showed varying levels of agreement between PEEK Acuity and Snellen chart, with 31% correct agreement, 59% agreement in one step, and 71% agreement in two steps. Indawati et al.[25] concluded that the average difference between the Snellen chart and PEEK Acuity was 0.1 logmar, with a coefficient of 0.65 and a level of conformity of 0.83. Bastawrous et al.[18] found an average difference between the ETDRS chart and PEEK Acuity of 0.011 log MAR and between the Snellen chart and PEEK Acuity of 0.078 log MAR. The results of this study show that the PEEK Acuity application has good accuracy in measuring visual acuity and can be relied on as an alternative to conventional visual inspection tools.[18],[22],[23],[24]

In Indonesia, several studies have been conducted to evaluate the reliability of the PEEK Acuity application in screening visual acuity in various sample groups. Indawati et al.[25] found that PEEK Acuity is an accurate and reliable visual acuity screening tool, equivalent to the Snellen chart in some specific patient populations. It allows PEEK Acuity to overcome barriers to accessing eye health services, especially in rural areas. The duration of the examination using PEEK Acuity was significantly shorter than that of Snellen charts in pre-school-age children.[21],[25]

Conclusions

The PEEK Acuity application can be considered as one of the feasible alternative applications in vision examination, especially for cases requiring a high specificity level to avoid errors in identifying cases that do not have vision problems. It is also easy to teach and can provide results quickly. PEEK Acuity can be used for training and is widely used by healthcare workers and teachers. Further research is needed to understand the effectiveness of the PEEK Acuity application more profoundly, and further development is needed to increase the accuracy of the results.

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