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Presbyopic Spectacle and Monovision for Reading Performance Before Adaptation

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Purpose: Eye movements and fixation ability are an important procedure to obtain external information and essential means of clear vision. The purpose of this study was to determine the reading performance such as reading time and number of fixations when random text was viewed at varying distances. **Methods:** Twenty two presbyopes were participated. All subjects were screened for their suitability to participate in the study by clinical examination, and none of the participants had previously worn contact lenses and no previous experience of wearing any types of presbyopic vision correction except single vision. The reading time and number of fixations were recorded using eye tracker while each subjects was waring four vision corrections which included single vision for distance (SV), bifocal spectacle lenses (BIF), progressive addition lenses (PAL), and monovision (MV). The reading material was presented at distance and near distance. **Results:** Reading time and number of fixations for near stimulus were significantly different among vision correction used in this study ($p<0.001$). In particular, wearing SV required longer reading time and produced longer fixation duration for near text. However, reading distance text was similarity performed across vision corrections tested and there was no statistical difference found for either reading time and number of fixations. **Conclusions:** Wearing presbyopic vision correction is advantageous for reading task of near stimuli, but not having near correction such as wearing SV could result in longer reading time and higher number of fixation due to lacks of accommodative ability for near task. For the future studies, it would be interesting to examine the performance of reading both at adapted and unadapted stages as examining only unadapted wearers was limitation of this study.

Key words: Progressive addition lenses, bifocal spectacle lenses, monovision, reading, fixation

Introduction

With the demographic transition toward an ageing population, there will be rapidly increasing number of people with presbyopia, which is an inevitable physiological change that occurs with age, resulting in a reduction in the clarity of near vision. While there are many interventions available to address the problems of presbyopia, wearing spectacles (i.e bifocal spectacles and progressive addition lenses) and contact lenses (i.e monovision) are easy and effective interventions for individuals who require clear distance and near vision within one optical correction. However, as there are many presbyopic vision corrections with different optical characteristics, it also affects visual function in different ways.

For instance, bifocal spectacle wearers often experience prism jump when eye moves across the line between the reading and distance segment, causing apparent displacement of objects[1],that can make negotiating stairs difficult[2]. Progressive addition lenses (PAL), as the most commonly dispensed spectacle lens for presbyopia[3], have also been reported to cause peripheral blur due to the gradual power progression across the centre of the lens[4]. Monovision (MV) results in diminished depth perception compared with a standard spectacle correction[5,6], and reductions in both distance and near acuity[7], and contrast sensitivity[8].

Even though previous studies have revealed that visual function is affected by wearing different presbyopic vision

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corrections, the impact of these changes on daily living such as reading text are poorly understood. This study therefore aimed to determine the reading parameters such as reading time and number of fixations when random text is viewed at varying distances.

Subjects

Twenty two individuals subjects were recruited to participate in this study (mean age of 48.1±4.2 years). All subjects were screened for their suitability to participate in the study by clinical examination, and none of the participants had previously worn contact lenses. Inclusion criteria were (1) no previous experience of wearing any types of presbyopic vision correction except single vision (SV) reading spectacles, (2) no ocular pathology (3) refractive error within the range of ±1.00D with less than −0.75D of astigmatism, (7) unaided visual acuity (VA) better than 0.2 logMAR in each eye. Informed consent was obtained from all participants, and the research protocol was approved.

The study involved a repeated measures design using four different visual optical corrections; SV for distance as a control vision correction, PAL, bifocal spectacle lenses (BIF), and MV. Plano lenses were prescribed for distance viewing and a+2.00D addition was prescribed for near for all participants. As the refractive error of subjects was within the range of ±1.00D, the distance VA of all participants was better than 0.0 logMAR with given prescription.

A 28 mm diameter flat top design bifocal lens was used for the BIF condition. For the PAL condition we used a commonly used design (conventional PAL design), which has an intermediate corridor width of 3.5 mm at point +1.25D in a typical +2.00 near addition[9], and distance zone width of the lens is approximately 10.5 mm at the level of the fitting cross.

For the MV condition, a disposable soft contact lens was used and 15 minutes of settling time was allowed before commencing the experiment. The dominant eye was fitted with a plano contact lens for distance vision and the non-dominant eye with the near prescription (+2.00D), following the conventional approach for prescribing MV[10]. Eye dominance was determined by the directional dominance sighting test, where participants were asked to extend their arms and form a small hole with both hands and binocularly centre a distance target in tha thole[11].

Reading material

As a reading material, 10 digit numeric numbers were used for distance and near stimulus. The numbers were displayed on a digital projector at 2m from subjects. The numbers on a A4 paper were presented at 40 cm for near test. The font was Arial and 12 respectively. Both of distance and near stimuli were presented 10 times per condition and mean of each measurement was used for analysis. Initially, each individual was instructed to view the centre of blank screen for distance numbers and the centre of A4 paper for near numbers. When random number is presented, the subject was instructed to view and report verbally from the first number to the last number presented.

Recording reading time and number of fixations

Number of eye fixations and reading speed while when viewing near and distance numbers were measured using an eye tracker (ASL Mobile Eye, Applied Science Technologies, Bedford, MA) which tracks the corneal reflections in one eye (Fig. 1). This eye tracking system has two cameras (eye and scene camera) which are mounted over the spectacle frames. Images from eye and scene camera were calibrated, then subject's fixation gaze where subject is looking at can be viewed on the image. The frequency of each camera is 30 Hz. The images from the eye and scene camera are then interleaved and recorded by a digital video cassette recorder (GV-D1000 NTSC, SONY). The data collected for analysis from the eye tracking system was analyzed using eye movement analysis software (Gaze Tracker) and the parameters for analysis included the number of fixations made while looking at

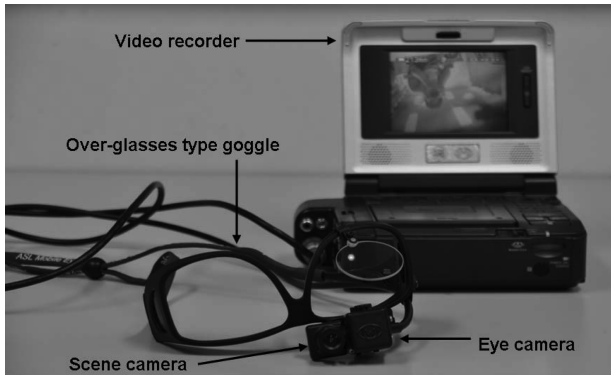

Fig. 1. Photograph of the Eye tracking system - ASL Mobile Eye.

the distance and near numbers. Fixation was defined as a static eye position lasting more than 0.1 sec. The reading time was calculated based on the time taken from first fixation to last fixation.

Analysis

The parameters (number of fixation and reading time) were analysed using repeated measures ANOVAs as the within-subjects variable. Where Mauchly's test was significant, and sphericity could not be assumed, the Greenhouse Geisser correction was used. If that ANOVA is significant, pairwise comparison as a post-hoc procedures was conducted to compare two means at a time.

Results

Reading time for near stimulus

Vision correction type had a significant effect on the total reading time on the near stimulus (ANOVA $F(2.4, 52.3) = 14.85$, $p < 0.001$). SV caused significantly longer reading time than all other vision correction types (pairwise comparison, $p \leq 0.024$). In addition, BIF and MV also required significantly longer reading time than PAL (pairwise comparison, $p < 0.01$). However, there was no significant difference between BIF and MV (pairwise comparison, $p > 0.05$) (Fig. 2).

Reading time for distance stimulus

There was no difference in the fixation duration for distance stimulus between correction types (ANOVA; $F(2.5, 53.1)=0.13$, $p>0.05$) (Fig 3).

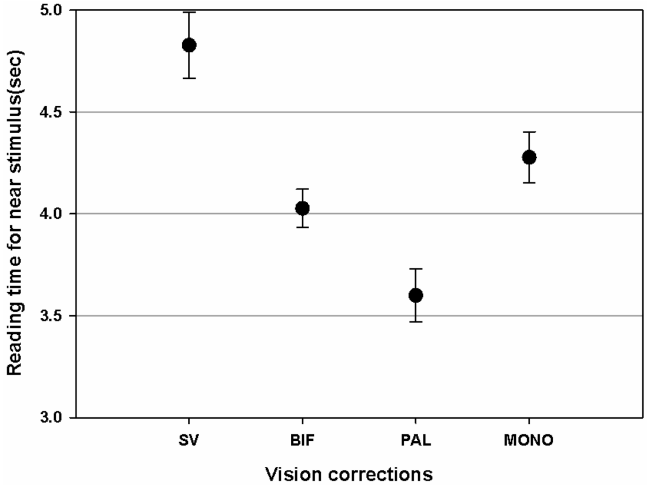

Fig. 2. Reading time for near stimulus by vision corrections (sec).

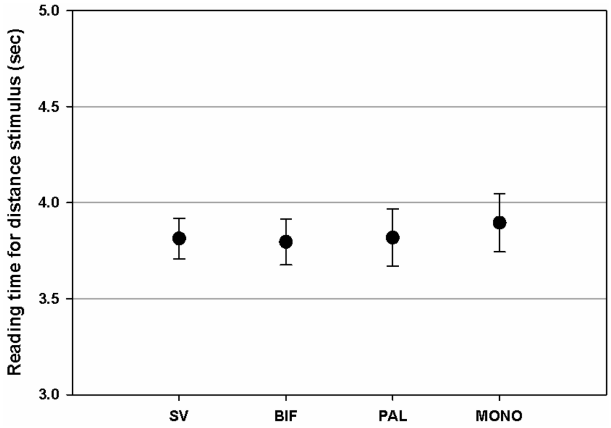

Fig. 3. Reading time for distance stimulus by vision corrections (sec).

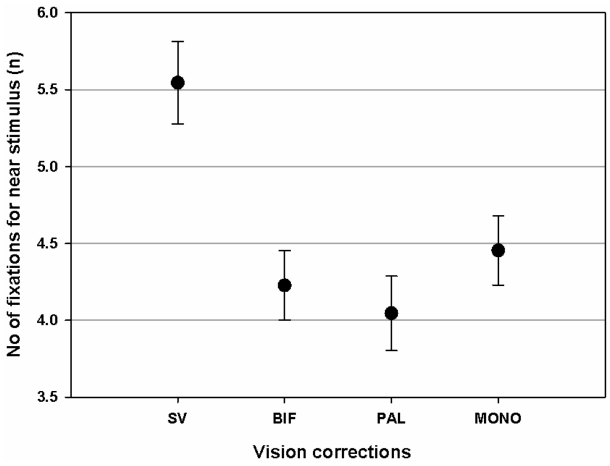

Fig. 4. Number of fixations for near stimulus by vision corrections (n).

Number of fixations for near stimulus

Vision correction type had a significant effect on the total number of fixations when viewing the near targets ($F(2.6, 54.1)=11.53$, $p<0.001$). SV resulted in significantly greater numbers of fixations than all of the other vision correction types (pairwise comparison, $p \leq 0.003$). However, there were no significant differences among BIF, PAL and MV (Fig. 4).

Number of fixations for distance stimulus

For the total number of fixations made when looking at the distance stimulus, there were no significant differences among SV, BIF, PAL and MV (ANOVA; $F(2.6, 54.9)= 1.56$, $p>0.005$) (Fig. 5).

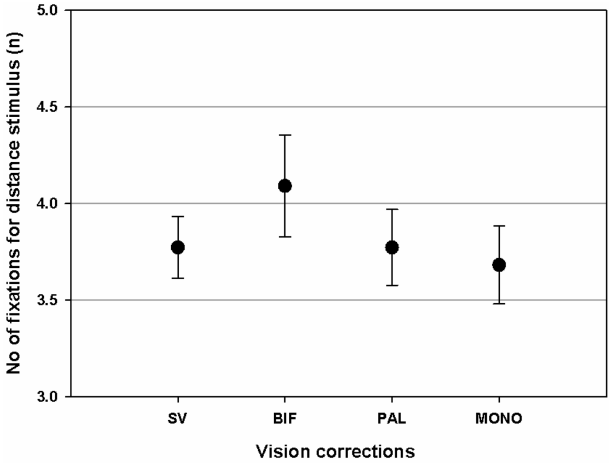

Fig. 5. Number of fixations for distance stimulus by vision corrections (n).

Discussion

This study demonstrated that wearing types of presbyopic correction can affect the fixation number and time when reading distance and neat texts.

The SV had significantly longer reading time and higher numbers of fixations than all the other vision corrections when viewing near targets. It has been suggested that longer fixation is related to extra processing time required to interpret the information[12]. Therefore, in this study, wearing SV unlike wearing presbyopic vision correction, BIF, PAL and MV, requires additional processing time to interpret the displayed numbers at near. This finding can be explained by the fact of presbyopia. Presbyopia is due to a loss of elasticity of the crystalline lens and capsule combined with changes in the ciliary muscle and choroid which become less efficient with ageing. This decrease in the flexibility and elasticity of the lens means that the lens cannot change shape to focus on near objects when the ciliary muscle contracts[13], therefore wearing only SV without near correction could cause hard time to focus on near objects resulting in longer fixation duration to figure out the text and this longer fixation duration also produces longer time taken to complete reading task while in particular wearing PAL would result in better performance for reading at near distance due to dedicated optical section for reading. Therefore, it is acknowledged that this result of better performance with PAL could be expected and it would be interesting if customized prescription is given to individuals for comparison among presbyopic vision corrections of BIF, PAL and MV.

This concurs with other study that SV made more errors compared to other presbyopic vision correction in recognition of near digital display which presented for 1.6 second[14]. In addition, SV wear would result in poorer clarity of the near targets, hence may produce a higher number of attempts to obtain a clear image on the near targets. Thus, blur unfocused images could cause several attempts or re-fixations to acquire clear images with wearing SV.

Among the presbyopic vision corrections in this study, there was no difference found with number of fixations for near stimulus. However, PAL showed better performance in reading time than both BIF and MV. This finding was not consistent with Brown and Collins's study that measured reaction time (button press task) of different types of presbyopic vision correction on targets of different distances (4m, 66 cm, and 33 cm)[15]. The target was made up of three LED dots and can be only discriminated with direct fixation. In their study, there was no difference in reaction time across the presbyopic spectacles (bifocal and trifocal) and presbyopic contact lenses (monovision, soft bifocal, concentric bifocal, modified monovision and hard bifocal contact lenses). This disagreement may be that Brown's study required simple perception while this study needed more detailed spatial vision which requires reading randomly presented text.

The well known limitations of MV are reduced stereoacuity and poor intermediate vision[15]. However,our finding indicated that viewing near target was not affected by wearing MV. Thus the effect of poor intermediate vision associated with MV correction did not result in significantly longer time for reading than the other presbyopic corrections such as PAL and BIF, while wearing MV performed better than wearing SV.

Adaptation to the visual correction may be an important factor affecting performance with presbyopic vision correction. As all participants in this study were naive wearers, therefore, the results may not necessarily reflect those of adapted presbyopic correction wearers. While this might be considered a potential limitation of this study, it does provide important information regarding the impact of unadapted presbyopic correction wear on aspect of reading performance. In addition, there have, however, been only a limited number of studies which have considered how

adaptation to presbyopic corrections might impact on performance. Sullivan and Fowler[17] reported that PAL wearers are known to subjectively report a period adaptation to their correction, which may also influence reading performance. Similarly, Hutchings et al.,[18] also examined how adaptation could affect head movement. In their study, they monitored extent of head movements before and after adaptation to PAL when undertaking a discrimination task at distances of 2m and 45cm and when reading text and showed that there was more head movements when adapted to PAL.

On the other hand, Han et al.,[19] found no significant differences between eye and head movements for either adapted or novice PAL wearers, however, their sample size was relatively small.

In contact lens wear regarding adaptation, Collins et al.[20] and Papas et al.[21] reported that the subjective impressions of visual performance were improved following a period of MV lens wear. However, various objective measures of visual performance fail to show significant improvement over similar time periods[20-22]. It is thus conceivable that subjects' visual performance with presbyopic contact lens corrections do improve after adaptation in ways that have not yet been established. It is possible that this improvement in visual performance and perceptual adaptations may alter eye movement parameters. Therefore,in future studies, it would be interesting to examine the performance of reading both at adapted and unadapted stages.

The number of fixations made when viewing distance text was around 3.7 to 4.1 and this did not approach any statistical difference across vision corrections tested in this study. Our failure to find any differences in any eye movement parameters for distance stimulus may have arisen because the size of the targets was typically large (requiring a VA of approximately 5 logMAR). Previous studies have shown slight reductions in VA and contrast sensitivity associated with MV compared to spectacle lens wear[8,10,16]. However, these reductions are small compared to the size of the distance targets used in this study.

Conclusions

Eye movement and fixation are a procedure to obtain external information, and reading is one of common task in modern life. This study demonstrated the advantage of having near correction on reading text at near distance but not having near correction such as wearing SV could result in longer reading time and higher number of fixation due to lacks of accommodative ability for near task. Therefore, not having near addition for presbyopes may express inefficient performance when reading at near text.

References

[1] Patorgis C. J. Presbyopia. In: Amos JF (ed), "Diagnosis and management in vision care", Butters worth Publishers, Stoneham, England, pp. 315-327(1987).

[2] Davies J. C., Kemp G. J., Stevens G., Frostick S. P., and Manning D. P., "Bifocal/varifocal spectacles, lighting and missed-step accidents", Safety Science, 38(3):211-226 (2001).

[3] Meister D. J. and Fisher S. W., "Progress in the spectacle correction of presbyopia. Part 1: Design and development of progressive lenses", Clin. Exp. Optom., 91(3):240-250 (1988).

[4] Sheedy J. E., "Correlation analysis of the optics of progressive addition lenses", Optom. Vis. Sci., 81(5):350-361 (2004).

[5] McGill E. and Erickson P., "Stereopsis in presbyopes wearing monovision and simultaneous vision bifocal contact lenses", Am. J. Optom. Physiol. Opt., 65(8):619-626 (1988).

[6] Gutkowski M. and Cassin B., "Stereopsis and monovision in the contact lens management of presbyopia", Bin. Vis. Q., 6:31-36(1991).

[7] Back A. P., Grant T., and Hine N., "Comparative visual performance of three presbyopic contact lens corrections", Optom. Vis. Sci., 69(6):474-480(1992).

[8] Collins M. J., Brown B., and Bowman K. J., "Contrast sensitivity with contact lens corrections for presbyopia", Ophthalmic. Physiol. Opt., 9(2):133-138(1989).

[9] Sheedy J. E., Hardy R. F., and Hayes J. R., "Progressive addition lenses--measurements and ratings", Optometry, 77(1):23-39(2006).

[10] Jain S., Arora I., and Azar D. T., "Success of monovision in presbyopes: review of the literature and potential applications to refractive surgery", Surv. Ophthalmol., 40(6): 491-499(1996).

[11] Bennett E. S., "Contact lens correction of presbyopia", Clin. Exp. Optom., 91(3):265-278(2008).

[12] Henderson J. M., Pollasek A., and Rayner K., "Covert visual attention and extrafoveal information use during object identification", Perception & Psychophysics, 45(3): 196-208(1989).

[13] Marmer, R. H., "The surgical reversal of presbyopia: a new procedure to restore accommodation", Int. Oph-

thalmic. Clin., 41(2):123-132(2001).
[14] Chu B. S., Wood J. M., and Collins M. J., "Influence of presbyopic vision correction on driving-related eye and head movements", Optom. Vis. Sci., 86(11):1267-1275(2009).
[15] Brown B. and Collins M. J., "Reaction times in a complex task by presbyopic observers with spectacle and contact lens corrections", Clin. Exp. Optom., 71(3):94-99(1988).
[16] Gupta N., Naroo S. A., and Wolffsohn J. S., "Visual Comparison of Multifocal Contact Lens to Monovision", Optom. Vis. Sci., 86(2):98-105(2009).
[17] Sullivan C. M. and Fowler C. W., "Analysis of a progressive addition lens population", Ophthalmic. Physiol. Opt., 9(2):163-170(1989).
[18] Hutchings N., Irving E. L., Jung N, Dowling L. M., and Wells K. A., "Eye and head movement alterations in naive progressive addition lens wearers", Ophthalmic. Physiol. Opt., 27(2):142-153(2007).
[19] Han Y., Ciuffreda K. J., Selenow A., and Ali S. R., "Dynamic interactions of eye and head movements when reading with single-vision and progressive lenses in a simulated computer-based environment", Invest. Ophthalmol. Vis. Sci., 44(4):1534-1545(2003).
[20] Collins M. J., Bruce A., and Thompson B., "Adaptation to monovision", ICLC, 21(11-12):218-224(1994).
[21] Papas E., Decenzo-Verbeten T., Fonn D., et al., "Utility of short-term evaluation of presbyopic contact lens performance", Eye Contact Lens, 35(3):144-148(2009).
[22] Sheedy J. E., Harris M. G., Bronge M. R., Joe S. M., and Mook M. A., "Task and visual performance with concentric bifocal contact lenses", Optom. Vis. Sci., 68(7):537-541(1991).

노안안경과 모노비젼 콘택트렌즈 착용 후 적응 전 읽기 능력 평가

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목적: 안구운동과 주시 능력은 독서 시 외적 정보를 얻기 위한 주요한 과정이며 명료한 시생활 조건의 주요한 매개변수로 작용한다. 본 연구는 주시 거리와 노안교정 방법의 다양한 조건에 의한 읽기능력과 주시 능력을 평가하기 위하여 시행하였다. **방법**: 평균 48.1±4.2세의 22명이 참여 하였으며, 각 피실험자는 실험에 적합한 선별검사를 실시하여 안질환이 없으며 이전에 콘택트렌즈 사용 경험이 없고 단초점 근용안경을 제외한 어떠한 형태의 노안교정 경험이 없는 대상자로 선별하였다. 읽기시간과 주시 횟수는 단초점렌즈(SV), 이중초점렌즈(BIF), 누진렌즈(PAL) 그리고 모노비젼(MV)를 한 상태에서 안구추적 시스템(Eye Tracking System, ASL Mobile Eye)을 사용하여 측정하였다. 읽기능력의 평가를 위한 원근 주시 거리는 2m, 40 cm에서 각각 시행하였다. **결과**: 근거리 읽기능력의 평가에 있어서 읽기시간과 주시 횟수는 본 연구에 사용된 단초점렌즈와 노안교정안경과 모노비젼 사이에 유의한 차이를 보였으나($p<0.001$), 특히나 단초점렌즈를 착용하였을 경우, 이중초점, 누진렌즈 그리고 모노비젼을 착용하였을 경우에 비해 읽기시간과 주시시간이 증가하였다. 하지만 원거리 읽기능력의 평가에서는 모든 조건에서 유사한 결과를 보였으며, 통계적으로 유의한 차이를 보이지 않았다. **결론**: 원거리와 근거리 시력의 교정을 목적으로 안경렌즈나 콘택트렌즈와 같은 노안교정방법의 사용은 근업시 읽기와 주시 능력에 도움이 될 수 있으나, 노안자에게 있어서 근거리 교정이 없는 단초점렌즈의 사용은 근거리에 대한 조절력 부족으로 인해 읽기시간의 증가와 주시 횟수 또한 증가함을 보였다. 추후 연구에는 본 연구에서는 노안교정의 무경험자를 대상으로 측정했으나 적응 능력을 고려한 노안교정 유경험자에 대한 연구를 기대할 수 있을 것이다.

주제어: 누진렌즈, 이중초점렌즈, 모노비젼, 읽기, 주시