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Ergonomic Enhancement for Older Readers with Low Vision

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Abstract: This study found that the provision of ergonomic workstations for 12 older persons with age-related macular degeneration who used low vision devices significantly increased the participants' reading speed and decreased their discomfort when reading.

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Age-related macular degeneration (ARMD) is the most prevalent cause of age-related visual impairment in all developed countries and accounts for approximately 67% of the legal blindness among U.S. veterans (De l'Aune & Williams, 2000). Of persons in the general population aged 75 and older, 1 in 3 has lost vision to this pathology (National Eye Institute, l999). The ability to read is the daily task that is most compromised by ARMD (De l'Aune, Williams, & Welsh, l999) because of the effect of macular loss on central vision (Schuchard, Naseer, & De Castro, 1999). The size of the resulting central scotoma, or blind spot, is a rate-limiting factor in reading with ARMD (Whittaker & Lovie-Kitchin, 1993).

The rehabilitation of reading usually requires the ability to use low vision devices, such as handheld or stand magnifiers, spectacle-mounted magnifiers, or closed-circuit television (CCTV) systems for reading. However, these devices complicate the reading process by their optical restrictions, including a close focal distance, small field of view, and short depth of focus. A CCTV system provides a greater focal distance, better contrast, and a wider field of view than do optical magnifiers; veterans who use CCTVs read for longer durations than do those who use optical magnifiers (Watson, De l'Aune, Long, Maino, & Stelmack, 1997b). Research has demonstrated that persons with ARMD can regain their reading accuracy and comprehension (Watson, Wright, & De l'Aune, 1992), but they cannot regain the reading rates or duration of sighted readers (Legge, Ross, Maxwell, & Luebker, 1989; Watson et al., 1997b).

Vision rehabilitation therapy is provided to veterans at

VA Blind Rehabilitation Centers, Blind Rehabilitation Outpatient Services, and Visual Impairment Centers to Optimize Remaining Sight. Studies have found that these service delivery models have proved vastly effective (De l'Aune et al., l999; Watson, De l'Aune, Long, Stelmack, & Maino, 1997a). Other studies have shown the effectiveness of rehabilitation instruction in the use of vision and optical devices for a variety of independent activities of daily living (Goodrich et al., 1999; Leat, Fryer, & Rumney, 1994; Nilsson, 1991). However, although low vision devices provide access to printed materials, they place demands on posture that may create tension, strain, and discomfort.

Principles of ergonomics that have been applied to workstations have shown that greater comfort and the lesser expenditure of energy can increase the work output of persons in a variety of situations (Kreighbaum & Barthels, 1996). Ergonomics can be defined as "1) the science of fitting the workplace to the worker, or 2) a biomechanical approach to workplace design" (Anshel et al., 1991, p. 54). The National Institute for Occupational Safety and Health (1997) estimated that more than 92,000 workplace injuries per year are directly related to issues of posture and/or repetitive movement. Postural deficiencies that are related to the design of workstations can cause numerous injuries or musculoskeletal disorders, including low back pain, sciatica, intervertebral disk degeneration, and lower limb edema (Kreighbaum & Barthels, l996). However, the principles of ergonomics in relation to readers with low vision have not been studied. Theoretically, positioning readers ergonomically should result in less discomfort and should increase performance as energy from the rest of the body is freed for reading.

Biomechanical studies have indicated that improper seating at a workstation can elevate motor-unit activation levels of the upper back and spinal musculature, causing significantly increased intervertebral disk pressure by placing the spine in hyperlordotic or kyphotic positions (Kreighbaum & Barthels, 1996). (Hyperlordosis is an accentuation of the lumbar curvature of the spine; kyphosis is the accentuation of the posterior curvature of the thoracic spine.) The result of these anatomically incorrect postures could lead to many of the previously mentioned maladies. With a population of older persons with visual impairments, improper ergonomics can lead to a greater propensity for discomfort and injury and a reduced ability to read.

This study was designed to answer two research questions: (1) Does an enhanced ergonomic workstation improve reading speed over a customary workstation for older persons with low vision, and (2) Does an enhanced ergonomic workstation decrease the subjective discomfort, increase the subjective comfort, and increase the perceived ability to read of these persons?

Methods

Participants

The participants were 12 persons, aged 70 and older, who had low vision because of ARMD (documented via ophthalmological reports). They had been prescribed low vision devices through the Department of Veterans Affairs or through local low vision services and had been using the devices for at least one year. The participants were recruited from the rolls of previous research subjects. However, none of the research projects in which they previously participated were related to the ergonomics of reading. The participants were informed of the procedures, risks, and benefits of the study and gave their informed consent via standardized procedures of the Emory University Human Consent Committee.

Procedure

The participants' cognitive functioning was assessed by the Folstein Mini-Mental Status Examination (Cockrell & Folstein, 1988); a score of 26 or higher out of 30 was required to ensure that their cognitive functioning was within normal limits. We used a score of 26, rather than the usual cutoff of 24, in consideration of the elevated cognitive demand for reading tasks.

The participants' near acuity and critical print size were measured via the Minnesota Low Vision Reading

Acuity Charts (MNRead) (Mansfield, Ahn, Legge, & Luebker, 1993); the participants read this test with their habitual prescriptive reading lenses in a bifocal correction at a standardized distance of 40 centimeters or 20 centimeters. The Morgan Low Vision Reading Comprehension Assessment (MLVRCA; Watson & Wright, 1996; Watson, Wright, De l' Aune, & Long, 1996) was administered to determine the grade-level equivalents (GLEs) for reading; the participants used their habitual low vision devices for reading this assessment (see Table 1). The participant's low vision devices included 9 CCTVs, 1 spectacle magnifier, 1 stand magnifier, and 1 handheld magnifier.

The participants' reading ability was tested at each of two workstations: an enhanced workstation or a customary workstation. The participants were randomly assigned (flip of a coin) to one of two ergonomic workstations, so that six participants performed at the enhanced workstation first, and six participants performed at the customary workstation first. The customary workstation for each participant was in his or her home where he or she customarily read, and which demonstrated typical (and sometimes poor) ergonomics for reading (Chaffen, 1991). For example, a subject's customary workstation might be a desk, the kitchen table, or an easy chair. The enhanced ergonomic workstation was individually designed for each participant in the reading laboratory of the Rehabilitation Research and Development Center of the Atlanta VA Medical Center.

The principles of ergonomics were used to design each participant's individualized enhanced ergonomic workstation (see Box 1). This enhanced ergonomic workstation provided seating, a desk, and a reading stand that were positioned and adjusted according to the principles of occupational biomechanics and ergonomics (Anshel, l994; Chaffen, 1991; Kreighbaum & Barthels, 1996). We used the Cornell University web-site parameters from *Ergonomic Guidelines for Arranging a Computer Workstation: 10 steps for users* (2001) and modified them for appropriate workstations for the use of low vision devices (CCTVs and optical magnifiers) according to recommendations by Lund and Watson (l997) (see Figure 1 and Figure 2). We used a height-adjustable and tilt-adjustable table and adjustable chair with lumbar and cervical support from an ergonomics company to adjust to the participants' various heights and body measures. We also provided a height- and tilt-adjustable reading stand to accommodate participants who used optical devices. We provided lighting for the workstations according to the clinical standard set forth by Carter (l983). If required in the enhanced ergonomic workstation, a participant was provided with a flex-arm incandescent or fluorescent lamp for additional lighting for use with magnifiers. The amount of light was set according to each participant's preference.

The participants read a total of four passages from the Gray Oral Reading Tests—4th Edition (hereafter Gray tests; Wiederholt & Bryant, 2001), two passages at each workstation. Two passages were chosen for the first workstation that were at, and immediately below, each participant's GLE, as measured by the MLVRCA for the first workstation, and two equivalent passages were taken from an alternate form of the Gray tests for the second workstation. For example, if a participant's measured GLE on the MLVRCA was 10, then the 9th and 10th GLE passages on one form of the Gray tests were administered at the first workstation, and the 9th and 10th GLE passages on an alternative form of the Gray tests were administered at the second workstation. The passages were equivalent in vocabulary, number of words, and GLEs between the two forms of the Gray tests. The participants' low vision devices were evaluated to ensure that the participants were able to achieve a critical print size, as measured by MNRead; if they were not able to achieve a critical print size, the passages from the Gray tests were enlarged to an appropriate critical print size for each participant. The participants' reading speeds were measured via a stopwatch for the two passages from equivalent forms of the Gray tests at each workstation. The data from the two passages in each workstation were summed to obtain an overall reading speed (see Table 2).

Visual analog scales (VASs) were used to measure the participants' perceptions on variables related to the two workstations. Following their reading in each workstation, the participants completed 10 VASs that asked them to rate their level of tension/discomfort in their eyes, head, jaw, neck, shoulders, back, hips, arms, legs, and feet. A higher score on these 10 variables indicates a less desirable outcome. The participants completed 2 additional VASs to rate their overall comfort in reading and their ability to read at each workstation. A higher score on these two variables indicates a more desirable outcome. The participants' marks on each VAS line were measured in millimeters (mm) from the left end of the line (the highest possible score was 120 mm). Differences in the VAS scores for the two workstations were analyzed (see Figure 3 for a sample VAS and directions; (see Figure 4 for the participants' ratings of each variable).

Results

The participants' reading speeds on the Gray tests and the results of the VASs were analyzed for differences between the two workstations. Our first research question can be answered affirmatively: The participants significantly increased their reading speed on the Gray test at the enhanced workstation compared to the customary workstation ($t = 2.847$, $p = .025$). Our second research question can be answered affirmatively as well: The participants' self-reports on the VASs for all areas with the exception of hip and leg discomfort were more positive for the enhanced ergonomic workstation than for the customary workstation. If these results were due only to chance, we would expect half the responses to be positive and half to be negative. A binomial expansion of the actual 10 positives out of the 12 variables measured by the VAS revealed that the probability of a random occurrence is .0193, a statistically significant positive *overall* effect of the enhanced ergonomic workstation. The small sample severely hampered the statistical power of independent statistical tests used on individual variables, but decreases in neck discomfort (t = 2.180, p = .057) and shoulder discomfort (t = 1.636, p = .136) in the enhanced ergonomic workstation approached statistical significance.

Discussion

Limitations

This study used a small, convenient sample of practiced participants with ARMD. The fact that this sample may not have been representative of the population of older readers with ARMD limits our ability to generalize the results. The small sample size set limits on the power of the statistical analyses of the second research question (related to comfort) by increasing the danger of Type II errors, the probability of accepting the null hypothesis (no difference between treatments) when it is actually false. This limited statistical power was especially a problem when error corrections for multiple independent statistical tests were used. In spite of these limitations, we believe that the information presented in this article is valid and serves a useful purpose in informing and reminding both professionals and consumers of the importance of ergonomic considerations in the use of low vision devices.

Implications for practice

Ensuring that persons who are using low vision devices for reading are positioned correctly may increase their rate of reading and decrease their discomfort when reading. We have provided the general heuristics used in this study for establishing enhanced ergonomic workstations for older readers with ARMD (see Box 1). The perceived decrease in neck and shoulder discomfort that approached significance in the enhanced ergonomic position could be accounted for by the fact that most of the participants were CCTV users, and these individuals positioned CCTV monitors atop their cameras and reading tables, resulting in excessive extension of the cervical spine (see Figure 5).

Physiological changes that accompany the aging process include sarcopenia (which is a progressive decrease in muscle mass that leads to frailty), reduced bone-mineral density, reduced maximum oxygen uptake, and reduced muscular strength. Morbidities related to these physiological changes include musculoskeletal instability, osteoporosis, reduced endurance, and a reduction in overall functional ability (Powers & Howley, 1997). If an ergonomically incorrect environment further stresses persons with these known age-related physiological changes, many may experience elevated levels of discomfort.

Although persons with low vision are able to regain reading ability, their performance with low vision devices is reduced compared to that of sighted persons. To complete the literacy activities that are important to independent living, such as reading a newspaper or paying bills, they must persevere for longer periods than sighted individuals would require because of their slow rates of reading. Reading slowly may be so discouraging for persons with vision loss that they stop trying to use their prescribed devices.

Conclusion

Readers who use low vision devices can benefit from short-term and inexpensive ergonomic interventions that significantly increase their reading speed and decrease their discomfort when reading. Ergonomic solutions presented in *Ergonomic Guidelines for Arranging a Computer Workstation: 10 Steps for Users* (2001) and by Lund and Watson (l997) and Carter (l983) can be easily adapted for any workstation by readers with low vision, their family members, and a wide variety of professionals in the field of low vision. The principles are easy to understand and easily implemented. Solutions need not be expensive to be effective.

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