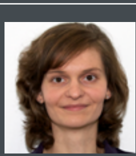
EFFECT OF MULTIFOCAL LENSES ON EYE AND HEAD MOVEMENTS IN PRESBYOPIC VDU USERS WITH NECK AND SHOULDER COMPLAINTS



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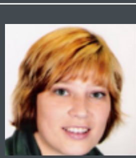

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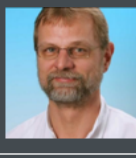

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__SUMMARY

The findings of this study suggest that in the case of presbyopic subjects with neck-shoulder discomfort, a VDU workplace may significantly contribute to the manifestation of a pathological stereotype (eye mover) in horizontal gaze shifts.
An optometric treatment based on multifocal spectacle lenses may be envisaged in presbyopic VDU users to reduce levels of neck and shoulder discomfort. The multifocal lens design typically induces more head movement in the horizontal direction, thereby reducing the levels of physical inactivity at VDU workplaces. Any relevant effects associated with the type of multifocal lens design could not be confirmed, although both the eye mover design and the occupational lens design contributed to a greater extent to the reduction in subjective neck and shoulder discomfort.
The influence on eye/head movement in the vertical direction was not investigated.

__INTRODUCTION

Computers have now become an integral part of today's work environment. In 2011, almost 21 million people in Germany had been working at visual display units (VDUs) [20], [5]. About 80% of individuals sitting in front of a PC for more than three hours a day usually complain about discomfort, including, for example, visual strain, headaches or pains in the neck and shoulder area [14]. According to *Hayes et al.* (2007) there is a correlation between eye and body symptoms in 81% of the cases as well as between eye strain and back/neck strain in about 64% of the cases [12].
Sitting in front of a computer screen will lead, in the long run, to unnatural postures (lack of movement, sustained immobile posture) as well as to changes in gaze shift behaviour [7]. Changes in the oculomotor function may also involve changes in neck muscle activation patterns [6].
The main focus of the study was to determine how the visual system is influenced by the optics and the design of an individualized multifocal spectacle lens. Von Buol (2002) has demonstrated that changes in eye and head movements occur depending on the type of eyeglasses and near addition [21]. According to Guillon et al. (1999) progressive addition lenses lead to higher amplitudes of head movement compared to single vision lenses [10]. *Selenov et al.* (2002) and *Han et al.* (2003) reported that not only the amplitude but also the frequency of head movements is higher in PAL wearers [16], [11]. There was no difference between the various types of lens designs [14].

The ratio of head and eye movements while fixating an eccentric target represents a typical and reproducible behaviour in each individual [17], [19], [9], [21]. In the literature, a distinction is made between two types of motor functions involved in gaze shifts [2], [9], [1]. Head movers mainly use head movements to identify a peripheral object (i.e. for gaze shifts with an amplitude of less than 10°). Eye movers mainly move their eyes while performing gaze shifts with an amplitude of more than 20°. In both types, however, the sum of head and eye movement amplitudes is identical and corresponds to the position of the peripherally fixated objects [17].
Beyer & Seidel 2007 reported that in patients with neck and shoulder complaints, the share of eye movers (eye movements contributing more than 50 % to gaze shifts) amounts to 90 % [3]. This percentage may in part be due to changes in combined eye/head movement when working at VDUs.

__PURPOSE

The purpose of this study was to investigate whether a multifocal lens design is able to influence individual levels of discomfort in VDU users suffering from neck and shoulder strain. The study involved testing three different lens designs. Specifically, the blurred vision areas in the periphery of the lenses should, over a three-month period, induce the subjects to use more head movements during lateral gaze shifts – with the aim of reducing levels of discomfort caused by neck and shoulder strain.

__MATERIAL AND METHOD

Study design
The subjects were randomized and single-blind divided into different interventions. Four groups were set up (Fig. 1). The subjects in group I, II and III (eye movers) were randomly given one of three different multifocal lens designs (Head/eye mover design or occupational lens). Group IV was the control group (comprising both head and eye movers) with no intervention.

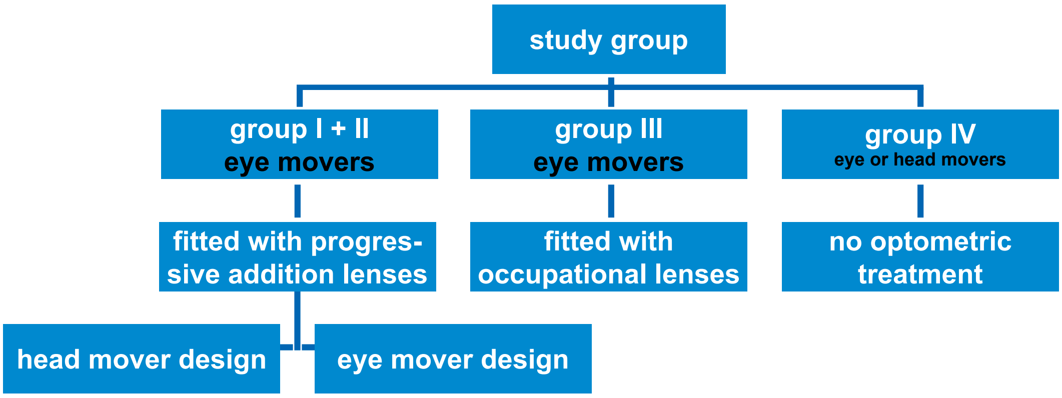

FIG. 1 | Splitting of subjects into different groups: groups I, II and III are provided with multifocal lens designs; group IV receives no optometric treatment

__TEST SUBJECTS

All subjects (n_0=122, 24 males and 98 females, aged 51,73 ± 4,46 years) showed an age-related reduction in their amplitude of accommodation and had already been wearing reading glasses, progressive lenses or bifocals prior to entering the study. They have all been working at VDUs (for more than 4 hours a day) and suffered from neck and shoulder discomfort (self-reported symptoms > 3 according to the visual analogue scale).

__LENS DESIGNS USED FOR THE STUDY

The spectacle frames and the different multifocal lens designs used under this study were provided free of charge by Essilor. The various types of lens designs were randomly allocated by the lens supplier. The designs included three different types of PAL's, a head and an eye mover design as well as occupational lenses ("mid-distance" variable focus lenses).

__TESTS

Assessment of individual discomfort levels

To evaluate subjective discomfort, the test persons were asked to assess their individual discomfort levels by using the Visual Analogue Scale (VAS) for the following question: "How would you rate your pain in the neck and shoulder area on a scale of 0 to 10, with 0 being no pain at all and 10 being the worst possible pain ?"

Determination of the head/eye ratio (HER)

In order to determine subjects' head to eye ratio, Essilor's Vision Print® System was used during the study (Fig.2) involving the determination of the head/eye mover ratio (HER) (mean value calculated from three measurements).

Optometric eye exams and tests

To test relevant optometric parameters under this study, standardized optical/optometric methods were used, i.e. visual acuity determination, refraction & determination of distance and near correction, heterophoria tests (using the Polatest) and finally determination of lens centration data.

Test procedure

The group of test subjects comprised both head and eye movers (n_0=122), half of them having received an optometric treatment. As these optometric interventions were to be tested on eye movers only, 61 subjects with typical eye mover gaze behaviour (HER: 0<x<=0.5 were randomly selected from the group of subjects. This selection was based on the examiners' assumption that most of the people working at VDUs are eye movers. These subjects were given VDU corrective spectacles fitted with multifocal lenses. After three months, a follow-up check was performed.

Data processing

Data from n=100 subjects could be evaluated before and after the study (study groups I, II and III n_V=52, control group n_K=48). For the complaints in the neck and shoulder area (SNA) and the head/eye ratio (HER), mean values and standard deviations were respectively calculated. Results were checked for statistical relationships between pre-study and post-study data.

__RESULTS

HER and discomfort levels across the entire study group before and after the study

In the investigated group of subjects, the HER ranged somewhere between 0 to 1 both before and after the study. On average, it rose from 0,36 ± 0,22 at the start of the study to 0,48 ± 0,22 at the end of the study. Consequently, after three months, the test subjects used more head movements for lateral gaze shifts than before the beginning of the study.

At the start of the study, 74% of subjects were classified as eye →

FIG. 2 | Determination of head movement and computation of the HER using the Vision Print® System from Essilor. The test person is sitting in an upright position about 40 cm away from the device and is holding onto a bar in the elbow to prevent the upper body from bending sideways. The subject follows the peripheral LEDs which are lit successively.

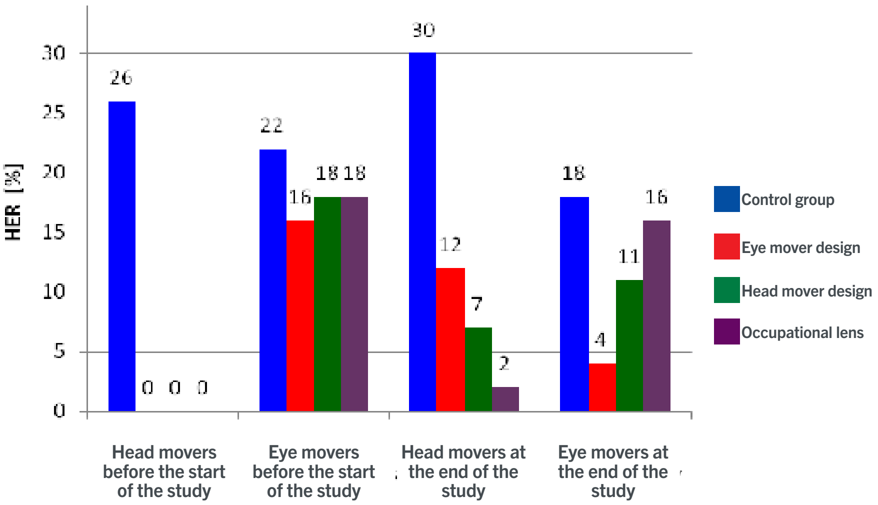

FIG. 3 | Percentage distribution of the head/eye ratio in the control group (n_K=48), in the group with eye mover design (n_E=16), in the group with head mover design (n_H=18) and finally in the group of subjects fitted with occupational lenses (n_A=18) before and after the study.

movers and 26 % as head movers. At the end of the study, 49% were categorized as eye movers and 51 % as head movers (n=100). The eye mover design induced the greatest change when switching from the eye mover 'type' to the head mover 'type' (0 percent head movers at the beginning of the study versus 12 percent head movers at the end of the study (Fig.3).

During the study, levels of neck and shoulder discomfort were reduced from 5,75 ± 1,35 (pre-study data) to 4,19 ± 2,08 (post-study data).

Assessing the effect of lens design types on subjects' HER and discomfort levels by comparing the four intervention groups before and after the study

The lens designs used under this study differed in the magnitude of peripheral defocus. The checking for differences between the groups in terms of lens design was based on the variation between pre-study and post-study data concerning HER and levels of neck and shoulder discomfort (Table 1).

	HER	Neck and shoulder discomfort
Control group	0,01 ± 0,17	-0,83 ± 1,94
Head mover design	0,22 ± 0,22	-1,61 ± 1,58
Eye mover design	0,22 ± 0,24	-2,50 ± 1,9
Occupational lens	0,15 ± 0,19	-2,61 ± 2,12

TAB.. 1 | Diifferences between pre-study and post-study data for HER and neck-shoulder discomfort levels as a function of the four interventions. The table includes mean values and standard deviations.

There is no reason to suppose that the different lens designs have had a varied effect on subjects' HER. The tendency for the change in the head-eye mover ratio in the direction of increased head movement is shown by comparing the pre-study data with the post-study data (head mover design pre-HER = 0,21 versus post-HER = 0,43; p=0,002; eye mover design pre-HER = 0,24 versus post-HER = 0,46; p=0,002; occupational lens pre-HER = 0,23 versus post-HER = 0,38; p=0,004 according to the Wilcoxon rank-sum test with α_{korr}=0,0083. The control group did not show any significant changes in head movement patterns (pre-HER = 0,49 versus post-HER = 0,5; p=0,577 according to the Wilcoxon rank-sum test).
A significant relief from neck and shoulder discomfort was achieved in each of the four groups (control group pre-SNA = 5,83 versus post-SNA = 5,0; p=0,003; head mover design pre-SNA = 5,44 versus post-SNA = 3,83; p=0,002; eye mover design pre-SNA = 5,5 versus post-SNA = 3,0; p=0,002; occupational lens pre-SNA = 6,06 versus post-SNA = 3,44; p=0,001 according to the Wilcoxon rank-sum test).

__DISCUSSION

Head/eye movement behaviour patterns in presbyopic subjects working with computer screens

In the investigated group of subjects (aged between 44 and 66) the share of head movers and eye movers amounted to respectively 26 and 74 percent (0,36 ± 0,22). Similar results were obtained by *Simonet et al.* (2003) with an average HER of 0,25 ± 0,23 ranging from 0 for eye movers to 0,98 for head movers [18]. These findings suggest that eye movers represent a higher percentage of the presbyopic population compared to head movers. It seems therefore realistic to assume that sustained fixation on VDU displays may explain this study outcome. However, these data do not provide conclusive evidence of whether eye mover behaviour exists due to subjects' age or presbyopic correction.
In a VDU-based work environment, all relevant zones typically lie within the field of view, eliminating the need to perform large-amplitude head movements to recognize objects. This results in a lack of movement and probably leads to changes in the way gaze shifts are performed. Hence, the working and environmental conditions of an individual seem to have a significant effect on eye/head movement behaviour.

__GAZE MOVEMENT «TYPE» AND DISCOMFORT LEVELS BEFORE AND AFTER THE STUDY

Head/eye ratio before and after the study

In the groups of subjects having received optometric treatment (eye mover / head mover design and occupational lens), a tendency for a change in the head-eye mover ratio in the direction of increased head movement is shown : after three months, the subjects increasingly used their head for lateral gaze shifts. As expected, the control group did not show any significant change in head movements. Consequently, the multifocal lens design must have had an effect on eye/head movements, whereas the type of lens design did not play any significant role. Nevertheless, most of the changes when switching from the eye mover 'type' to the head mover 'type' were achieved through the eye mover design. In addition, as regards the reduction of neck/shoulder strain, the eye mover design and the occupational lens were found to perform better than the head mover design.

In this study, the HER was determined in the horizontal direction only. However, in the case of progressive addition lenses, this direction strongly depends on the subjects' near addition. Therefore, an additional study should involve investigating the eye/head movement behaviour in the vertical direction in subjects with identical near add powers

Levels of neck and shoulder discomfort before and after the study

Most of the people working at VDUs suffer from neck and shoulder strain [14], [12]. According to *Richter* (2008) intensive near-work may lead to an increase in ciliary muscle tone and/or a decrease in convergence [15]. But also changes in extraocular muscle tone could go hand in hand with a stress-induced increase in oblique muscle tone which may result in both headaches and back pains.

During the study, a reduction in neck and shoulder complaints could be shown in the groups with optometric treatment by comparing pre-study data with post-study data. Control subjects, too, showed a significant reduction in complaints in the neck and shoulder area, which is possibly due to the Hawthorne effect or to uncontrolled variables (holidays, physiotherapy) during the study period. The fact that the subjective assessments of discomfort levels were identical across all study groups could also be explained by the very nature of the multifocal lens design : the multifocal eyeglass not only induces head movement restrictions in the horizontal but also in the vertical direction. In the case of progressive addition lenses, this often leads to an unnatural head position. Hence, this aspect should be further investigated in a follow-up study.

__CONCLUSIONS AND OUTLOOK

With regard to eyecare for VDU users, better account will have to be taken of an individual's workplace requirements as well as of their physiological and/or anatomical needs, especially in the case of presbyopic patients. This involves taking into account the design of VDU workplaces that should be optimized where needed (ex : monitor distance and inclination). This does not necessarily mean that the spectacles need to be adapted to the existing workplace. Instead, both aspects need to be accounted for and should be made compatible. To summarize, VDU workplaces should be designed so as to allow as much movement as possible and the use of alternate task breaks throughout the workday.

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