Work 41 (2012) 3433-3437
DOI: 10.3233/WOR-2012-0620-3433
IOS Press

Visual ergonomics interventions in mail sorting facilities

H. Hemphälä[a*], G-Å. Hansson[b], C. Dahlqvist[b] and J. Eklund[c]
[a]*Division of Ergonomics and Aerosol Technology, Design Sciences, Lund University, P.O. Box 118, SE-221 00 Lund, Sweden*
[b]*Division of Occupational and Environmental Medicine, University Hospital, SE-221 85 Lund, Sweden*
[c]*Division of Ergonomics, School of Technology and Health, Royal Institute of Technology, KTH, Alfred Nobels Allé 10, SE-141 52 Huddinge, Sweden*

Abstract. This study was performed between 2004 and 2011 at mail sorting facilities in Sweden. During this time, different interventions were performed. The first was a lighting intervention that had a positive impact on the postal workers, especially those with eyestrain. A new lighting system also improved the illuminance and gave better light distribution. The second intervention involved new personal spectacles for the postal workers who needed them and this had a positive effect on eyestrain. The third intervention involved a specific type of sorting spectacles for the postal workers who already used progressive lenses privately. The reading distances that the postal workers had while sorting the mail was inverted to the distances in their regular progressive lenses. The new sorting spectacles had a positive effect on head postures and on muscular activity.

Keywords: illuminance, lighting, progressive lenses, EMG, inclinometry

1. Introduction

"The eyes lead the body" [3]. When there is a problem seeing, the body adjusts its posture to make it easier to see.

Aarås et al. [1,2] performed a large ergonomic intervention study of video display unit (VDU) operators that included lighting. They found that lighting and optometry are of crucial importance in reducing musculoskeletal disorders (MSD). Both mail sorting and VDU work is visually demanding, and a good visual environment is important for health and well-being.

The frequency of musculoskeletal pain among people with incorrect lenses in their glasses is higher than among those with correct lenses. A single vision lens or a work progressive lens is better for working with computers than a regular progressive lens [12]. Studies show that individuals with eyestrain also report musculoskeletal strain to a higher degree than those without eyestrain [11,5].

Dentists have a large head/neck flexion while working that leads to neck strain. In a study by Lindegård et al. [15], they found a decrease in the head/neck flexion when using specifically designed prismatic spectacles, allowing the dentist a more natural working posture.

A relationship between the eyes and muscles has been found by some researchers [14,17,18], but the exact mechanism behind this needs some more exploration.

Luminaires that are mounted in the wrong place, depending on where the light is needed, can cause shadows or reflected glare in the working material [4]. Insufficient illuminance levels or low uniformity levels can also affect the ability to work, which is why the uniformity of the task illuminance should not be less than 0.7 [6]. According to Veitch [19], a working area should have uniform illuminance while the surrounding areas should be non-uniform, but not causing glare. The aspects of lighting that can cause visual discomfort are: too little light, too much light, too much variation in illuminance between and across working surfaces, disability glare, discomfort glare, veiling reflections, shadows, and flicker [5]. The color rendering index (CRI) and the correlated color temperature (CCT) are important for a comfortable visual environment, but there seems to be cultural differences in preference of the CCT [5].

* Corresponding author. E-mail: hillevi.hemphala@design.lth.se.

1.2 The purpose of the study

The purpose of this visual ergonomics intervention study was to evaluate the visual environment in mail sorting facilities and to explore opportunities for improving the work situation by reducing visual strain, improving the visual work environment and reducing mail sorting time.

The hypothesis was that incorrect lighting, incorrect power in lenses and incorrect type of lenses may cause eyestrain, and that visual problems may contribute to MSD, all of which may affect productivity.

To improve the visual environment, the lighting should have a more uniform illuminance, higher illuminance and less glare.

To improve the visual system, the participant's spectacles should be up to date and the individuals who need progressive lenses should also be given a pair of specifically designed sorting spectacles due to the inverted distances at the sorting rack. See Fig. 1.

Figure 1. The sorting rack with the new lighting. The top shelf should be at shoulder height for the postal worker.

2. Methods and Materials

The first three parts of this longitudinal study involved a lighting intervention. The fourth and fifth parts were different spectacles interventions. See Table 1.

The first part took place before any interventions were made, in the summer of 2004 (n=27). The second and third parts were follow-up studies carried out after the lighting intervention, in the summer of 2006 (n=25) and winter 2006-2007 (n=23). In these three sub-studies, the lighting was measured and the postal workers responded to questionnaires with questions about their subjective opinions of their visual environment, wellbeing, eyestrain, and musculoskeletal strain. In accordance with Knave et al. [13], an eyestrain index was calculated to determine the degree of eyestrain syndrome. The postmen were also timed when sorting 150 C5 letters. For more details about these first three parts of the intervention study, see Hemphälä et al. 2012 [11].

The fourth part of the study was performed after the postmen had received new individually fitted personal spectacles (February 2008, n=18). In the autumn of 2007, visual examinations were carried out on all of the postmen in the study and they were provided with the type of spectacles that their vision needed. The postmen evaluated their visual environment, personal eyestrain and musculoskeletal strain via questionnaires, the same questionnaire used in the first three parts of the study.

In the fifth part of the study, 12 postmen who used progressive lenses received a pair of specifically designed sorting spectacles in September 2010. When they sorted letters with regular progressive lenses, they had to bend their heads backward in order to read the top shelf and bend their heads down in order to see the lower shelf. The distances to the different shelves were approximately 40 cm to the top shelf and 80-90 cm to the bottom shelf; the distance to the letters in hand was approximately 40 cm. The sorting spectacles had double frames and flip up spectacles; the posterior frame had the correct power for distant vision and the anterior frame contained a pair of work progressive lenses mounted up-side-down, with the left lens on the right eye and the right lens on the left eye (Gradal RD by Zeiss Vision). This meant that the postmen did not have to bend their heads backward when looking at the top shelf, but they had to bend their heads forward a bit more when reading the letters in their hands compared to the regular progressive lenses. They could just look down when reading on the lower shelf. When looking at a distance, they just flipped up the anterior frame

Table 1
The different parts of the intervention study performed 2004-2011.

Intervention Studies at Mail Sorting Facilities			
Part 1	Before lighting intervention	Summer 2004	n=27
	Lighting intervention	Autumn 2004	
Part 2	After lighting intervention	Summer 2006	n=25
Part 3	After lighting intervention	Winter 2006-2007	n=21
	Personal spectacles	Summer 2007	n=21
Part 4	After spectacles intervention	Winter 2008	n=18
	Specific sorting spectacles	September 2010	n=12
Part 5	Testing sorting spectacles	May 2011	n=12

and only looked through the posterior frame.

The postmen got the sorting spectacles more than six months before the study was performed and the progressive spectacles before that. In May 2011 they sorted 150 C5 letters with both their progressive and sorting spectacles, the same letters sorted twice in random order. Half of the postmen started sorting with the progressive spectacles and half with the sorting spectacles. The time it took to sort the letters was recorded. The postmen were asked how often they had used the sorting spectacles before the study.

During the sorting, surface electromyography (EMG) and inclinometry were measured. The EMG measurements were performed on the descending parts of the m. trapezius with bilateral bipolar recordings using Ag/AgCl electrodes. Data were normalized to the maximal EMG activity (maximal electric activity: MVE) derived during three maximal voluntary contractions. This was done for all measurements performed as arm abductions against resistance proximal to the elbow with the arms raised to 90° in the scapular plane. Muscular rest, defined as fraction of time with an activity <0.5% MVE, and the 10^{th}, 50^{th}, 90^{th} and the 99^{th} percentiles of the amplitude distributions, were used to describe the muscular activity. For details, see Hansson et al. [9,10] and Nordander et al. [15,16].

Inclinometers, based on triaxial accelerometers (Logger Teknologi HB, Åkarp, Sweden), were used for recording the inclination relative to the line of gravity for the head and the upper back [7,8]. The inclinometers were fixed with double-sided adhesive tape to the forehead and the upper back. The reference positions (0° of flexion/extension) of the head and upper back were recorded with the subject standing upright and looking straight ahead. Neck angles were calculated as head angles minus upper back angles. Positive values denoted flexion and negative extension.

3. Results

3.1. The lighting intervention (parts 1-3)

Illuminance before the intervention did not attain the recommended uniformity value of 0.7 for any of the participants. The mean uniformity value was 0.55. After the intervention, the uniformity increased to 0.67. The average illuminance increased from 550 lux with the old lighting to 950 lux with the new lighting.

The postmen's perception of the lighting improved with the new lighting. The individuals with eyestrain rated the old lighting lower than the individuals without eyestrain. With the new lighting there were no differences between the groups.

Before the lighting intervention, 44% of the postmen had eyestrain. After the lighting intervention in the summer follow-up, 32% had eyestrain. But during the winter follow-up study, 47% experienced eyestrain.

There were also differences in productivity between the individuals with and without eyestrain. Those with eyestrain sorted slower before the lighting intervention, a difference that disappeared after the lighting intervention.

Eyestrain for those aged over 45 increased after the intervention. The younger group had a reduced amount of eyestrain.

The individuals in part one with eyestrain had 2.9 times as much musculoskeletal strain compared to the individuals without eyestrain; in the second part, it was 3.7 times higher.

The younger group, under 45 years, had a decrease in musculoskeletal strain.

3.2. After the spectacles intervention

The preliminary results show that after the intervention 17% (compared to 47%) of the postmen had eyestrain (winter 2008). They also experienced an improvement of their vision.

3.3. The sorting spectacles

The preliminary results show that head postures and muscle activity improved with the sorting spectacles. With the progressive spectacles, the postmen tilted their heads backward when looking at the top shelf. The sorting spectacles resulted in better head posture, with less back tilt.

The muscle activity for the right m. trapezius was reduced with the sorting spectacles.

Six of the postmen sorted slower with the sorting spectacles than with the personal progressive spectacles; three had no difference and three sorted faster with the sorting spectacles.

4. Discussion

The workplace lighting improved for the postmen. Unfortunately, the general lighting sometimes worsened the effect of the well-planned workplace lighting with uneven lighting distribution and disability glare. The uniformity value improved, but if the general lighting would have been changed, this value could have been even better.

The postmen's eyestrain was also slightly reduced with better lighting. With new personal spectacles it improved a great deal. There were only three left, out of the original 18, with the eyestrain syndrome after they got new spectacles: one of them had cataracts with sensitivity to light as a classic sign of that. This left two younger postmen with eyestrain that cannot be explained by incorrect power in their spectacles.

The individuals with eyestrain before and after the lighting intervention had the best improvement in productivity. Good lighting seems more important for those with eyestrain.

The best effect of the lighting intervention was observed with the younger postmen, resulting in less eyestrain, less musculoskeletal strain and increased productivity.

After the post men received new individually fitted personal spectacles, the amount of individuals with eyestrain decreased. Correct power in lenses can decrease eyestrain.

With the sorting spectacles there was no clear change in productivity. This may be caused by the fact that most of the mailmen did not notice any differences between the two spectacles. So they did not use the sorting spectacles as much as they should; it takes a while to get used to them. They had been instructed to only use the sorting spectacles while sorting for two weeks before the day of the study. But it seemed that they did not really do this.

Head posture was improved by the sorting spectacles, towards less back tilt of the head.

The EMG activity for the right m. trapezius showed decreased activity. The postmen held the mail with their left hand (unfortunately in a very static position) and sorted the mail into the sorting racks with their right hand. They are more relaxed in their right arm with the sorting spectacles. This might correlate to the longer sorting time for some of the postmen.

5. Conclusion

To decrease individual eyestrain, the entire visual environment must be considered, not just providing the employees with new glasses.

This study shows that good lighting can improve productivity among individuals with eyestrain, when the existing lighting is insufficient with too low illuminance, glare and low uniformity value.

Correct power in spectacles and good lighting can decrease eyestrain. Specific working spectacles for individuals that need progressive lenses can improve working posture and might decrease MSD.

Incorrect lighting and incorrect power in lenses can cause eyestrain. Improvement of these reduces eyestrain and MSD. It may also improve productivity.

Acknowledgements

Special thanks to the Swedish Post Office, Svenska Posten AB, for letting us perform these studies, and to the postal workers that participated. We would like to thank Carl Zeiss Vision AB, Sweden, for sponsoring the postal workers with their lenses, making the final parts of this study possible. Thanks to Optergo and Per-Johan Pettersson who provided us with the flip-up frames. Synoptik Lund was kind enough to lend us rooms that we used to examine the post workers' eyes. We would also like to thank Per Nylén, Roger Wibom, Peder Wibom, Kalev Kuklane and Chuansi Gao for their help and support in these studies. This study was supported in part by the Swedish Council for Work Life and Social Research, AFA Insurance, Lund University Medical Faculty, and the County Councils of Southern Sweden.

References

[1] A. Aarås, G. Horgen, H. Bjørset, O. Ro and H. Walsøe, Musculoskeletal, visual and psychosocial stress in VDU operators before and after multidisciplinary ergonomic interventions, Applied Ergonomics, 29(5) (1998), 335–354.

[2] A. Aarås, G. Horgen, H. Bjørset, O. Ro and H. Walsøe, Musculoskeletal, visual and psychosocial stress in VDU operators before and after multidisciplinary ergonomic interventions. A 6 years prospective study – Part II, Applied Ergonomics, 32(6) (2001), 559–571.

[3] J. Anshel, Visual Ergonomics Handbook, Taylor & Francis Group, Boca Raton, Florida, USA, 2005, ISBN 1-56670-682-3.

[4] ANSI/IESNA, American National Standard Practice for Office Lighting, Illuminating Engineering Society of North America, 2004.

[5] P.R. Boyce, Human factors in lighting, Taylor & Francis, Cornwall, 2003. ISBN 0-7484-0950-5.

[6] CIE, Commission Internationale de l'Éclairage, ISO 8995, CIE S 008/E, Lighting for indoor work places, International Standard, 2002.

[7] G-Å. Hansson, P. Asterland, N-G. Holmer and S. Skerfving, Validity and reliability of triaxial accelerometers for inclinometry in posture analysis. Med Biol Eng Comput 39 (2001), 405–413.

[8] G-Å. Hansson, I. Åkesson, K. Ohlsson, C. Nordander, S.E. Mathiassen, S. Skerfving and I. Balogh, Precision of measurements of physical workload during standardised manual handling. Part II: inclinometry of head, upper back, neck and upper arms, J Electromyogr Kinesiol 16 (2006), 125–136.

[9] G-Å. Hansson, P. Asterland and S. Skerfving, Acquisition and analysis of whole-day electromyographic field recordings, in: H.J. Hermens, G. Hägg and B. Freriks, eds., European Applications of Surface Electromyography. Proceedings of the Second General SENIAM (Surface EMG for Non Invasive Assessment of Muscles) Workshop Stockholm, Sweden, 1997, pp.19–27. ISBN: 90-75452-06-3.

[10] G-Å. Hansson, C. Nordander, P. Asterland, K. Ohlsson, U. Strömberg, S. Skerfving and D. Rempel, Sensitivity of trapezius electromyography to differences between work tasks – influence of gap definition and normalisation methods. J Electromyogr Kinesiol 10 (2000), 103–15.

[11] H. Hemphälä and J. Eklund, A visual ergonomics intervention in mail sorting facilities: effects on eyes, muscles and productivity, Applied Ergonomics 43 (2012), 217–229.

[12] G. Horgen, The effect of optometric corrections on visual discomfort and musculoskeletal pain in visual display unit workers, Buskerud University College, Department of Optometry and Visual Science, 2003. ISBN 82-080-073-5.

[13] B. Knave, R. Wibom, U. Bergqvist, L. Carlsson, M. Levin and P. Nylén, Work with video displays terminals among office employees, I, II, III, and IV, Scandinavian Journal of Work, Environment & Health 11 (1985), 457-487, ISSN 0355-3140.

[14] I. Lie and R. Watten, VDT work, oculomotor strain, and subjective complaints: an experimental and clinical study, Ergonomics 37(8) (1994), 1419–1433.

[15] C. Nordander, G-Å Hansson, L. Rylander, P. Asterland, J.U. Byström, K. Ohlsson, I. Balogh and S. Skerfving, Muscular rest and gap frequency as EMG measures of physical exposure: the impact of work tasks and individual related factors. Ergonomics 43 (2000), 1904–1919.

[16] C. Nordander, I. Balogh, S.E. Mathiassen, K. Ohlsson, J.U. Byström, S. Skerfving and G-Å. Hansson, Precision of measurements of physical workload during standardised manual handling. Part I: Surface electromyography of m. trapezius, m. infraspinatus and the forearm extensors, J Electromyogr Kinesiol 14 (2004), 443–454.

[17] H.O. Richter, T. Bänziger, S. Abdi and M. Forsman, Stabilization of gaze: a relationship between ciliary muscle contraction and trapezius muscle activity. Vision Research 50 (2010a), 2559–2569.

[18] H.O. Richter, T. Bänziger and M. Forsman, Eye-lens accommodation load and static trapezius muscle activity, European Journal of Applied Physiology 111 (2010b), 29–36. doi:10.1007/s00421-010-1629-x.

[19] J.A. Veitch, Psychological Processes Influencing Lighting Quality. National Research Council of Canada, Ottawa, NRCC-42469, 2001.