# THE VISUAL LOAD DUE TO MAN-MACHINE WORK (COMPUTER, DIGITAL DEVICES)

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**Abstract.** Prolonged use of computers and digital devices can lead to various physical and mental health problems. This study sought to assess computer and digital device ergonomics (CDDE) of designers, photographers, IT professionals, accountants and suppliers in several Bulgarian firms and to determine the visual (VS) and musculoskeletal (MS) symptoms reported by the respondents.

In the study, a survey was made, through a survey, using a Google Form. 42 participants were surveyed, within two weeks, in 3 age groups: up to 30 years, from 30 to 40 years and over 40 years. A significant proportion of employees reported various symptoms of VS and MS. The most affected parts of the body are identified: neck, arm/shoulder/wrist and waist. Special attention is paid to eye strain, and the symptomatology is most often related to visual symptoms, such as eye fatigue, eye pain, sensitivity to light, and others. The research covers significant issues related to health care and the importance of ergonomics in practice.

**Keywords:** Computer vision syndrome, Eyestrain, Glare Flicker, Vision, Posture

## 1    Introduction

Visual load is due to human-machine work, which is often static and continuous when using digital devices such as computers, laptops, tablets, smartphones and other electronic devices. The eyes focus in the emitting light and this leads to Computer Vision Syndrome (CVS) or Digital eye strain. (Jeffrey R., 2007; Mork R. et al, 2018; Marwa M. 2018). Eye strain is also often caused by too bright light, either from outside sunlight coming in through a window or from strong indoor lighting. (Gary Heiting, 2019, Szabó G. et al., 2021)

According to the American Optometric Association, CVS is "A complex of near vision problems that occur during or are related to computer use." (American Optometric Association (1995). The thesis is also confirmed by others investigating the problem of CVS. (Zetterberg K. et al., 2019; Hashemi H. et al., 2017)

CVS causes blurred vision, headaches, dry eyes, sensitivity to light (photophobia), along with these symptoms, the muscles in the neck and shoulders are also activated, this also causes Musculo-skeletal Symptoms (MS). Neck, back and lower back pain are being most common symptoms in MS. (Szabó G. et al., 2021, Gerr et al. 2002; Mohammadi Z. et al 2020; Mork R. 2018; www.moeto-zdrave.com)

Computers and other digital devices are widespread today, used both professionally and for lei-sure. Computer workers are subjected to visual stress. Between 60% and 90% of users experience symptoms of CVS, such as dry and irritated eyes, eye strain/fatigue, blurred vision, red eyes, burning eyes, exces-sive tearing, double vision, headaches, sensitivity to light/glare, slow shift in focus and changes in color perception. 22% of computer workers have musculoskeletal problems. (Mork R., (2018);  Ranasinghe P.0, (2016); Rosenfield M. (2011); Anshel J.(2002)

The most common factors that contribute to digital fatigue and CVS are poor lighting, glare from a digital screen, inappropriate viewing distances, poor sitting posture, uncorrected vision problems, a combination of these factors.

The extent to which people experience visual symptoms often depends on the level of their visual ability and the amount of time spent looking at a digital screen.(Heiting G. 2019; Middlesworth M. 2022)

Each year, over 10 million consumers visit eye specialists for problems related to dry eye syn-drome. (Dain, S., 1988). About 75% of the population working in front of a monitor for 6-9 hours a day complains of some eye discomfort. Over 70% of people who regularly use a computer develop asthenopia (visual fatigue) (Bedinghaus T., OD, 2022; Ocomed, 2017)

Deficiencies in the ergonomics of the monitor and in particular its placement, the presence of glare reflected on the screen, inappropriate viewing distances, window location, room light (artificial, natural, mixed) were also associated with reported visual symptoms. Independent variables such as age, length of employment, job type, daily computer work hours, and work pattern indicate partici-pants' reported experience in different MS and VS.

Both MS and VS are associated with ergonomic deficits in computerized workplaces. Appropriate strategies, work practices and preventive measures are needed to eliminate the occupational risks associated with computerized workplaces. To minimize these risks it is important to take regular breaks (the 20-20-20 rule: for every 20 minutes spent looking at a screen, look away at something 20 meters away for 20 seconds (https://www.healthline.com/health/eye-health/20-20-20-rule#definition; https://opto.ca/eye-health-library/20-20-20rule;https://www.medicalnewstoday.com/arti-cles/321536#how-to-use-it), to maintain good body posture; to select suitable light in the room to pre-vent glare on the screen; to eliminate reflection or direct light on the worker's face; adjust screen brightness and contrast; to select a suitable font and background of the work area, to apply moisturizing drops to the eyes of the worker with the Computer and digital devices(CDD).

## 2      Materials and methods

One of the best methods of collecting data and information is online forms. Tool of this report is Google Form. A survey was conducted among 42 participants from several Bulgarian companies and freelancers. The questions are divided into 3 categories by age: up to 30 years, from 30 to 40 years and over 40 years. The professional positions of the participants are: Designers, Photographers, IT special-ists, Accountants and Suppliers.

In the three categories, questions were asked about the duration of computer use (hours per day and years), the type of digital device they use; level, type of the monitor and its distance from the Operator; using an anti-reflective screen or glasses with such a coating to reduce glare from the screen (Kamlesh M., 2018); frequency of eye strain (sensitive to light, red eyes, eye pain, tearing, eye fatigue, double vision, frequent blinking, headache); preventive as rest every 40 minutes, eye massage, eye drops; ex-periencing pain during prolonged work with a computer in the neck, shoul-ders, lower back, arm/wrist; work posture (sitting, standing);  location of the window, relative to the one working with the CDD (left, right, front, back) light in the room (natural, artificial or mixed); whether importance is attached to the size and style of the fonts located on the screen; are they aware that the size of the font must be adapted to the visual perception, as it is necessary to balance the working space reducing the strain on the eyes when working with digital devices; what color style/theme do they use at work – white, black or colored background.

## 3      Research results

The research was conducted, through a survey, among 42 participants, within 2 weeks. Up to 30 years old answered 9 participants (21.4%), from 30 to 40 years - 5 participants (11.9%) and over 40 years old - 28 participants (66.7%). (see Fig.1)
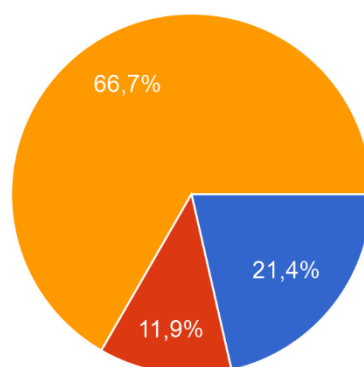
**Fig. 1.** Age groups of the respondents

### 3.1 Up to 30 years of age

Survey in this age group with 11 participants.

According to the professional position, they are: Designers - 4 (36.4%), Photographers - 3 (27.3%), IT specialists - 2 (1.2%), Accountants - 1 (9.1%) and Suppliers - 1 (9.1%). (see Fig. 2a)

Duration of use of computer and digital devices (CDD), (see Table 1a)

— over 10 years - 6 (54.5%)
— from 5 to 10 years – 2 (18.2%)
— under 5 years – 3 (27.3%)

Type of digital device: computer often/every day (O) used by 8 participants, rarely (R) – 2; laptop: 9 (O), 2 (R); Tablet/iPad/Note: 1(O), 7(R); Smartphone: every day - all 11 participants. (see Fig. 3a)

Most of the respondents work more than 6 hours/day with a computer/laptop - 6 people (54.5%), from 3 to 6 hours/day - 3 (27.3%) and less than 3 hours/day 2(18.2%). (see Table 2a)

The monitor screen is positioned at eye level or slightly below eye level (for 10 of the respond-ents), 7 participants indicated that their screen is located at a distance of 50-60 cm from their eyes, but for the majority the monitor is not is tilted at an angle of 10 to 20 degrees 6(No), 3 (Yes). (see Table 3a)

Everyone who works with CDD is exposed to the risk of CVS. Participants in the survey receive symptoms such as sensitivity to light 6 often (O), 4 rarely (R), 1 never (N); red eyes 1(O), 5(R), 5(N), eye pain 4(O), 2(R), 5(N); watery eyes 4(N), 3(R); eye fatigue 6(O), 4(R); double vision 5(N), 5(R); eye blinking 2(O), 3(R), 5(N); headache 3(O), 4(R), 4(N). (see Table 4a)

In addition to the visual load, those working with CDD also have problems with the musculoskel-etal system (MS). Most often they get pain in the back 6(O), 3(R), 2(N), less often in the neck 4(O), 2(R), 5(N), hands, wrists 4(O), 2(R), 5(N), and shoulders 3(O), 4(R), 4(N). (see Fig. 4a)

All participants up to 30 years of age work in a sitting position. (see Table 5a). The window is to the right (45.5%), to the front(27.3%), to the left (18.2%), and 9.1% to the back of the worker looking at the monitor screen. (see Fig. 5a)

Mixed lighting dominates the workplace (72.7%), natural lighting - 18.2%  and artificial lighting - 9.1%. (see Table 6a)

70% of the respondents under the age of 30 attach importance to the size and style of the fonts lo-cated on the screen (see Table 7a), but a smaller part (40%) are aware that the size of the font should be consistent with the visual perception, as it is necessary to balance the working space, reducing the strain on the eyes when working with digital devices. (see Table 8a)

7(70%) are those who use a color style/theme at work in which a white background prevails, an-other part 6(60%) prefer a black background and 1(10%) prefer a colored background. (see Table 9a)

#### Preventions

8 (72.7%) of 11 participants use an anti-reflective screen or glasses with such a coating to reduce glare from the screen.(see Table 10a)

Take a break every 40 minutes 5(Yes), 6(No), eye massage 4(Yes), 7(No), apply drops to moistur-ize the eyes 4(Yes), 7(No). (Table 11a)

## 3.2  From 30 to 40 years of age

The respondents in this age group are 5 participants.

According to professional position: Designers1(25%), Photographers 2(50%), Accountants 1(25%), 1 did not answer. (see Fig. 2 b)

4(80%) of the participants in the survey indicated duration of use of CDD over 10 years, and 1 (20%) from 5 to 10 years.  (see Table 1b)

And in this age group they most often work with a laptop 4(O), 1(R), a smaller part of the respondents work with a computer 3(O), 1(R). All respondents use a smartphone every day 5(100%). (see Fig. 3b)

2 (40%) of the respondents indicated the duration of working with the CDD over 6 hours/day with a computer/laptop, from 3 to 6 hours/day - 2(40%) and under 3 hours/day - 1(20%) . (see Table 2b)

For most participants, the monitor is located at or below eye level 3-Yes, 1-No, tilted at an angle of 10 to 20 degrees 2-Yes, 3-No, at a distance of 50-60 cm from the eyes, 1-Yes, 2-No. (see Table 3b)

The most frequent complaints related to CVS are eye fatigue 3(O), 2(R), when working with CDD. Other symptoms such as sensitivity to light 1(O), 2 (R), eye pain 1(O), 3(R), lacrimation 3(R), double vision 2(R), eye blinking 1(O), 2(R), and headache 2(O), 2(R). (see Table 4b)

MS symptoms that they get after long-term work with CDD are neck pain 3(O), 2(R), shoulder pain 3(O), 2(R), lower back 2(O), 1(R), arm /wrist 2(O), 1(R). (see Fig. 4b)

Participants in this category also work only in a sitting position (100%). (see Table 5b)

In relation to the monitor screen, the worker's window, in this age category, is located on the left 2(40%), on the right 1(20%), in front 1(20%), behind 1(20%). (see Fig. 5b)

The light in the room is mixed 2(40%), natural 2(40%), artificial 1(20%).(Table 6b)

4(80%) give importance to the size and style of the fonts located on the screen, only 1(20%) answered that it does not matter. (see Table 7b)

4(80%) are not aware that the size of the font should be adapted to the visual perception, as it is necessary to balance the workspace reducing the eye strain when working with digital devices, only 1(20%) is aware. (see Table 8b)

A white background with black letters is the most preferred color style/theme they use at work. (see Table 9b)

### Preventions

Almost all consumers 4 (80%) in this age group use an anti-reflective coating forscreen or glasses to reduce glare from the screen. (see Table 10b). Take a break for 40 minutes, they answered that they do not do 4(No), eye massage 2(Yes), 2(No), put drops to moisturize the eyes 2(Yes), 3(No) (see Table 11b).

## 3.3  Over 40 years of age, participants are 27

By professional position: Designers 4(14.8%), Photographers 5(18.5%), IT specialists 5(18.5%), Accountants 8(29.6%) and Suppliers 5(18.5%). (see Fig. 2c)

The duration of use of CDD, as assumed in this age category, is the greatest - over 10 years 24(88.9%), from 5 to 10 years 2(7.4%) and under 5 years is only 1(3 .7%) of the participants. (see Table 1c)

A greater part of the respondents use CDD on a daily basis. They work with a computer 18(O), 2(R), laptop 18(O), 7(R), use Tablet/ iPad/ Note 3(O), 11(R), smartphones 23(O). (see Fig. 3c)

The duration of use of CDD per day was more than 6 hours 21(77.8%), from 3 to 6 hours 2(7.4) and less than 3 hours 4(18.8%). (see Table 2c)

The level of the monitor in most participants is at or slightly below eye level 21(Yes), 2(No), inclined at an angle of 10 to 20 degrees is only in 4, the distance from the eyes to the screen is 50-60 cm on 17 of the participants. (see Table 3c)

The frequency of eye strain is different for everyone. They have sensitivity to light 7(O), 13(R), Red eyes 4(O), 17(R), Eye pain 3(O), 11(R), Tearing 6(O), 9(R), Eyestrain 16(O), 8(R), Blinking 2(O), 15(R), Headache 5(O), 12(R). (see Table 4c)

In this age category, MS complaints are more frequent by extended computer or digital device use. Neck pain 12(O), 11(R), shoulder pain 9(O), 9(R), low back pain 12(O), 12(R), arm/wrist 12(O), 11(R).

(see Fig. 4c)

Almost all participants work in a sitting position: 26(96.3%)-Yes, 1(3.7%)-No, works in a stand-ing position. (see Table 5c)

Relative to the screen, the window is located, on the left 6(23%), on the right 11(42.3%), in front 7(26.9%), behind 2(7.7%). (see Fig. 5c)

The light in the room is mixed 17(63%), artificial 4(14.8%) and natural 6(22.2%). (see Table 6c)

A greater part of the respondents attach importance to the size and style of the fonts located on the screen 21 (77.8%-Yes), and 6 (22.2%-No). (see Table 7c)

10 participants (40%) were aware that the size of the font should be consistent with the visual perception, as it is necessary to balance the workspace reducing the eye strain when working with digital devices, 15(60%) were not aware. (see Table 8c)

A greater part use color style/theme of work in white color 23(85.2%), in black color 6(22.2%) and in color - 5(18.5%). (see Table 9c)

**Preventions**

Not everyone uses an anti-reflective coating for screen or glasses to reduce glare from the screen 11(Yes-40.7%), 16(No-59.3%). (see Table 10c),

A little more than half take a 40-minute break 13(Yes), 11(No), eye massage 6(Yes), 18(No), put drops to moisturize the eyes 7(Yes), 16(No).(see Table 11c)
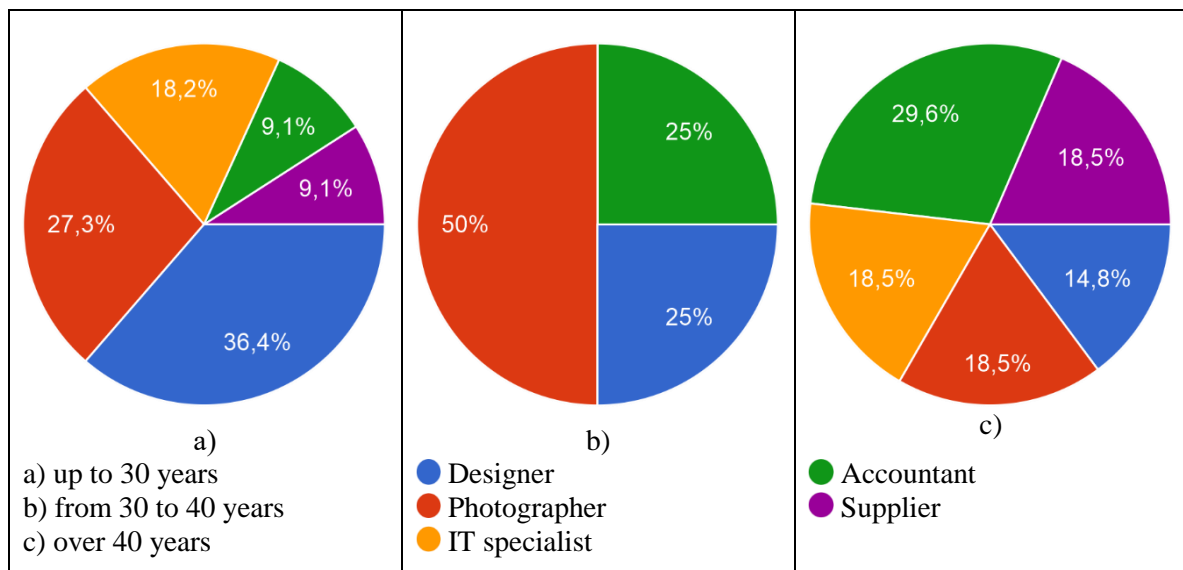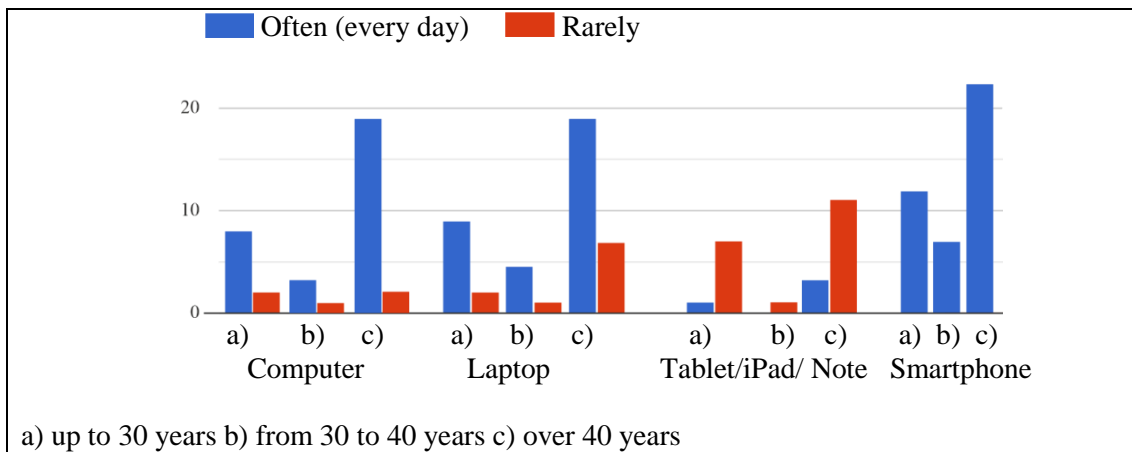


**Fig. 2.** Professional position.

**Table 1.** Duration of computer use

|  | a) | b) | c) |
|---|---|---|---|
|  | up to 30 years | from 30 to 40 years | over 40 years |
| Under 5 years | 18,2% | 20% | 7,4% |
| From 5 to 10 years | 27,3% | 40% | 3,7% |
| Over 10 years | 54,5% | 40% | 88,9% |

**Fig. 3.** Type of digital device used by all participants

**Table 2.** Duration of computer/laptop use per day

|  | a) | b) | c) |
|---|---|---|---|
|  | up to 30 years | from 30 to 40 years | over 40 years |
| < 3 hours | 2(18,2%) | 1(20%) | 2(14,8%) |
| 3 to 6 hours | 3(27,3%) | 2(40%) | 4(7,4%) |
| > 6 hours | 6(54,5%) | 2(40%) | 21(77,8%) |

**Table 3.** The monitor screen is on

|  |  | a) | b) | c) |
|---|---|---|---|---|
|  |  | up to 30 years | from 30 to 40 years | over 40 years |
| eye level or slightly lower | Yes | 10 | 3 | 21 |
|  | No | 1 | 1 | 2 |
| Inclined at an angle of 10 to 20 degrees | Yes | 3 | 2 | 4 |
|  | No | 6 | 3 | 11 |
| distance 50-60 cm from the eyes | Yes | 7 | 1 | 17 |
|  | No | 2 | 2 | 4 |

**Table 4.** Frequency of eye strain

|  |  | a) | b) | c) |
|---|---|---|---|---|
|  |  | up to 30 years | from 30 to 40 years | over 40 years |
| Sensitive to light | Often | 6 | 1 | 7 |
|  | Rarely | 4 | 2 | 13 |
|  | Never | 1 |  | 5 |
| Red eyes | Often | 1 | 2 | 4 |
|  | Rarely | 5 | 2 | 17 |
|  | Never | 5 | 1 | 4 |
| Eye pain | Often | 4 | 1 | 3 |
|  | Rarely | 2 | 3 | 11 |
|  | Never | 5 |  | 10 |
| Tearing up | Often | 4 |  | 6 |
|  | Rarely | 3 | 3 | 9 |
|  | Never | 4 | 1 | 8 |
| Eyestrain | Often | 6 | 3 | 16 |
|  | Rarely | 4 | 2 | 8 |
|  | Never | 1 |  | 1 |
| Double vision | Often |  |  | 2 |
|  | Rarely | 5 | 2 | 10 |
|  | Never | 5 | 2 | 12 |
| Blinking eyes | Often | 2 | 1 | 2 |
|  | Rarely | 3 | 2 | 15 |
|  | Never | 5 | 1 | 7 |
| Headache | Often | 3 | 2 | 5 |
|  | Rarely | 4 | 2 | 12 |
|  | Never | 4 |  | 9 |



a) up to 30 years b) from 30 to 40 years c) over 40 years
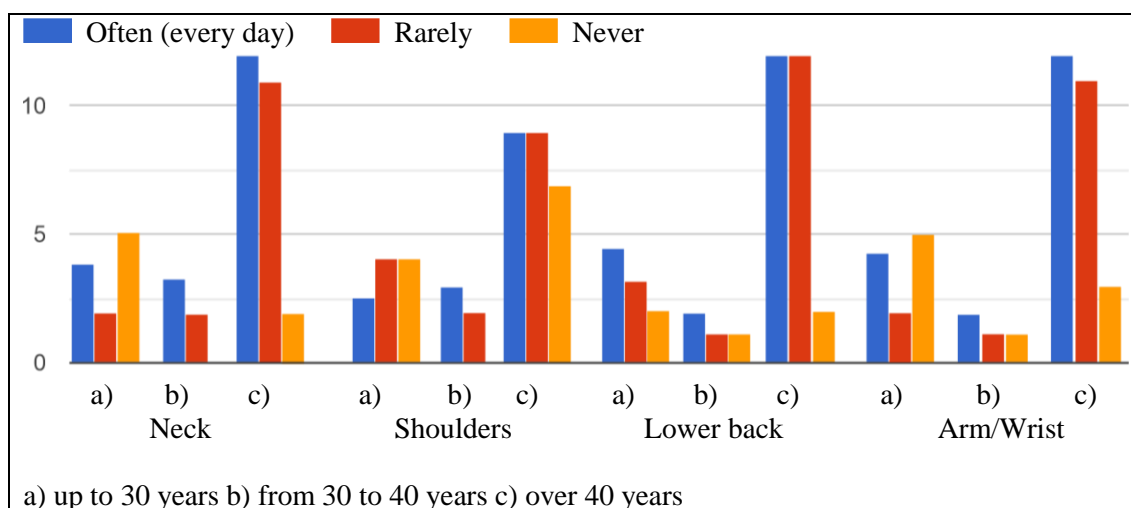
**Fig. 4.** Pain during prolonged computer work

**Table 5.** Posture at work

|  | a) | b) | c) |
|---|---|---|---|
|  | up to 30 years | from 30 to 40 years | over 40 years |
| Sitting | 100% | 100% | 26(96,3%) |
| Standing |  |  | 1(3,7%) |
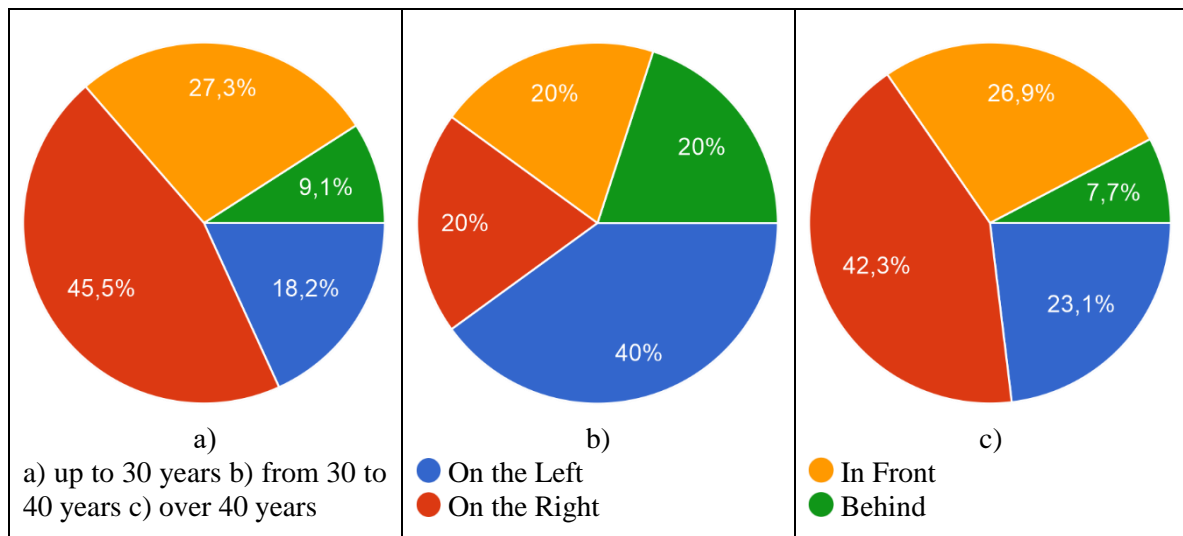
**Fig. 5.** Location of the window relative to the monitor screen

**Table 6.** Light in the workplace

|  | a) | b) | c) |
|---|---|---|---|
|  | up to 30 years | from 30 to 40 years | over 40 years |
| Natural | 1(9,1%) | 2(40%) | 6(22,2%) |
| Artificial | 2(18,2%) | 1(20%) | 4(14,8%) |
| Mixed | 8(72,7%) | 2(40%) | 17(63%) |

**Table 7.** Do you pay attention to the size and style of the fonts located on the screen

|  | a) | b) | c) |
|---|---|---|---|
|  | up to 30 years | from 30 to 40 years | over 40 years |
| Yes | 70% | 80% | 77,8% |
| No | 30% | 20% | 22,2% |

**Table 8.** Are you aware that the size of the font should be adapted to the visual perception, as it is necessary to balance the working space reducing the strain on the eyes when working with digital devices?

|  | a) | b) | c) |
|---|---|---|---|
|  | up to 30 years | from 30 to 40 years | over 40 years |
| Yes | 40% | 20% | 40% |
| No | 60% | 80% | 60% |

**Table 9.** What color style/theme do you use at work ?

|  | a) | b) | c) |
|---|---|---|---|
|  | up to 30 years | from 30 to 40 years | over 40 years |
| White | 7(70%) | 5(100%) | 23(85,2%) |
| Black | 6(60%) |  | 6(22,2%) |
| Colorful | 1(10%) |  | 5(18,5%) |

**Table 10.** Do you use an anti-reflective screen or glasses with such a coating to reduce glare from the screen ?

|  | a) | b) | c) |
|---|---|---|---|
|  | up to 30 years | from 30 to 40 years | over 40 years |
| Yes | 72,3% | 80% | 40,7% |
| No | 27,3% | 20% | 59,3% |

**Table 11.** Preventions

|  |  | a) | b) | c) |
|---|---|---|---|---|
|  |  | up to 30 years | from 30 to 40 years | over 40 years |
| Break every 40 minutes | Yes | 5 |  | 13 |
|  | No | 6 | 4 | 11 |
| Eye massage | Yes | 4 | 2 | 6 |
|  | No | 7 | 2 | 19 |
| Moisturizing eye drops | Yes | 4 | 2 | 7 |
|  | No | 7 | 3 | 16 |

## 4    Conclusions.

Based on the conducted survey, it was concluded that in most workplaces the light in the room is mixed, the window is located in front or behind about 40%, which leads to visual stress and eye strain. As a consequence of the visual load, by avoiding, reducing or eliminating glare, the posture of the worker becomes incorrect and MS occurs. Therefore, several factors must be taken into account:

- The brightness of the light should be half as much as usual in offices. Position the monitor screen so that the windows are on the right or left, instead of in front or behind the screen, in order to reduce glare on the screen;
- To replace the old monitor (CRT) with a flat panel (LED screen) with an anti-reflective surface; The optimal placement of the upper edge of the screen should be at an angle of 15-20° (10-13 cm) from eye level and 50-70 cm away from them. Adjust CDD display settings to reduce eye strain and fatigue: refresh rate as high as possible, above 75 hertz (Hz). Adjust the display brightness(if the white background looks like a light source, then it is too bright, if it looks dull and gray, it may be too dark); Adjust the size and contrast of the text (black text on a white background is best); To lower the color temperature of the display to lower the amount of blue light emitted by the color display for better long-term viewing comfort.
- Minimizing glare: putting an anti-reflective screen or glasses with an anti-reflective coating putting blinds on the windows, putting protective covers on the screen. When the outside light cannot be reduced, the walls in the room should have a darker, matte finish.

To minimize these risks, it is important to take regular breaks (every 20 minutes, the gaze focuses on 20 meters for 20 seconds, also every 40 minutes to take a 15-minute break).

Maintain good posture at work, blink frequently to moisten eyes, and use moisturizing drops. The top line of the screen should be at or slightly (0-30 degrees) below eye level. Getting up and moving, whenever possible. Suitable adjustable work furniture.

## Acknowledgments

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