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# Web-Based Office Ergonomic Intervention on Work-Related Complaints

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## Abstract

Previous research has shown that office ergonomic training by experts can result in a reduction of employees' work-related complaints. The aim of the present study was to examine the effects of an office ergonomic intervention on self-reported musculoskeletal disorders, headache symptoms and eye strain. For this purpose, a website was established, presenting information and a guidance tool in a simple way for individual ergonomic adjustments of computer workstations. Employees in an office department had the task to adjust their computer workplaces on the basis of the provided information. Results indicate that 96% of the employees adapted their workplaces. Moreover, self-reported musculoskeletal disorders and headache symptoms decreased after the intervention significantly. The study pointed out that the established website is a cost-effective and simple alternative to expensive and time-consuming expert training for improving ergonomics and health in offices.

# Introduction

During the last years the amount of computer use at work has increased rapidly. In the European Union (EU) 50% of women and 45% of men work on computers every day (European Foundation for the Improvement of Living and Working Conditions, 2007). Further, occupational illnesses such as musculoskeletal disorders and psychological stress increased in the last years (Federal Institute for Occupational Safety and Health, 2011). A lack of effective protection for ensuring health and safety at work can result in absenteeism, occupational illness, and permanent occupational disability. This has an extensive negative effect on the affected human as well as on the resulting economic costs (Commission of the European Communities, 2007). Lundberg and Johannson (2000) pointed out that about 30% of musculoskeletal costs are work-related, although it has been difficult to relate these disorders to light physical work as working at a computer. However, in the last years several studies indicated an association between computer work and occupational illnesses such as musculoskeletal disorders (Amick et al., 2003; Robertson, 2007), eye strain (Aarås, Horgen, & Helland, 2007; Jaschinski, Heuer, & Kylian, 1998), as well as psychosocial stress (MacDonald, Karasek, Punnett, & Scharf, 2001; Laitinen, Saari, Kivistö, & Rasa, 1998). Work-related musculoskeletal disorders are the impairment of bodily structures such as muscles, joints, tendons, ligaments, nerves, or bones, typically affected at the back, neck, shoulders and upper limbs. Most work-related musculoskeletal disorders are cumulative and develop over time. The symptoms range from discomfort and pain to reduced bodily function and invalidity (European Agency for Safety and Health at Work, 2008). For preventing and reducing these symptoms in an office environment, an ergonomic basic setting of the sitting position is essential. Therefore, the chair and the table should be adjusted so that the legs and arms are at right angles. Further, the backrest of the seat should be adjusted in order to support the back. In that way, the spine gets relieved and muscles are relaxed (Kleinhenz, 2011).

Another work-related illness in association with computer work is eye strain including burning eyes, flickering, fatigue and blurred vision. Further, headache plays a role which can be caused by unadjusted workplaces (Paul, 2003). Jaschinski et al. (1998) emphasized that the position of the computer monitor relative to the eyes can influence eye strain. Further, the kind of visual aid has an impact on the appropriate positioning of computer screens. For experiencing the advantages and disadvantages of the monitor position relative to the eyes

Jaschinski, Heuer, and Kylian (1999) developed a 5-day test procedure for subjects with normal vision. On four days, subjects placed the monitor each day in a distinct position: low and near, at eye level and near, low and distant, at eye level and distant. At the last day, subjects adjusted their screen individually to their preferred position. The results indicated that subjects with normal vision preferred distinct monitor positions concerning the distance between eyes and monitor as well as monitor inclination. However, monitor at eye level or at a shorter distance to the eyes induced stronger eye strain and visual discomfort compared to a monitor positioned lower or at a greater distance. These results are supported by the physiological functions of the visual system that the eyes at rest are declined relative to horizontal (Menozzi, Buol, Krueger, & Miège, 1994). With increasing age, the ability to focus near objects declines which is referred to as presbyopia. The use of respective progressive addition lenses for having clear vision continuously from distant to near objects has an impact on the appropriate monitor positioning. Many users tilt their neck back for having a clear vision through the lower near vision part of the glasses to the monitor. For avoiding such forced postures it is recommended to place the monitor at a low position with a vertical gaze inclination relative to the monitor (Jaschinski, 2008; Lie & Fostervold, 1995). Moreover, subjects using bifocal lenses are recommended to position the monitor to an individual comfortable height and at a distance until having clear vision. The inclination of the monitor relative to the gaze inclination should be vertical (Krueger, 1989).

In general, employees using computers should be provided with adjustable office furniture including chairs (Amick et al., 2003; Groenesteijn, Blok, Formanoy, de Korte, & Vink 2009), tables as well as adjustable computer monitors (Zeller & Jaschinski, 2005). However, providing adjustable office furniture alone is often not sufficient (Robertson, 2007). Recent studies indicated that the awareness of office ergonomics has to be raised by training the employees (Amick et al., 2003; Robertson, 2007). By means of ergonomic interventions, work-related disorders in an office environment can be prevented or reduced (Amick et al., 2003; Ketola et al., 2002; Brisson, Montreuil, & Punnett, 1999). A successfully implemented office ergonomic intervention can result in an increased ability of the employees to change their work environment, leading to an enhancement in the reduction of work-related complaints and individual effectiveness (Amick et al., 2003; Aarås, Horgen, Bjørset, Ro, & Walsøe, 2001). Huang, Robertson, and Chang (2004) demonstrated that giving employees control over their physical work environment can enhance their physical health and performance. In the previous studies, a common intervention form was a personal office ergonomic training of the employees (Amick et al., 2003; Robertson, 2007). However, this method is time consuming and requires special experts teaching. The present study used another approach for providing information on office ergonomics. For this purpose, a web-based intervention was established in order to have employees adjust the workplaces under their own control and in a conscious way. Further, it provides the possibility to gather information at any time. The created website contains ergonomic information on essential basic settings with reference to the chair, table, keyboard and lighting, as well as information on the adjustment of the monitor in dependence of the visual aid.

The aim of the present study was to investigate the effects of a web-based office ergonomic intervention on self-reported musculoskeletal complaints, headache symptoms and eye strain. On the basis of previous findings it is presumed that the intervention leads to a behavioral change so that subjects will adjust their workplaces which will remain to be used after the intervention (see Figure 1). To describe this ergonomic condition, the following four variables were used: monitor inclination, head inclination, gaze inclination, and viewing distance. Moreover, self-reported complaints are supposed to be reduced after the intervention. For this purpose, the three dependent variables musculoskeletal complaints, headache complaints, and eye strain were used. Based on previous findings it is expected that chair adjustments (Amick et al., 2003; Groenesteijn et al., 2009), a greater viewing distance (Jaschinski et al., 1999) as well as a lowered head inclination (Kleinhenz, 2011) will result in fewer self-reported musculoskeletal complaints. Further, it is expected that a greater viewing distance and a lowered gaze will result in fewer eye strain (Jaschinski et al., 1999).

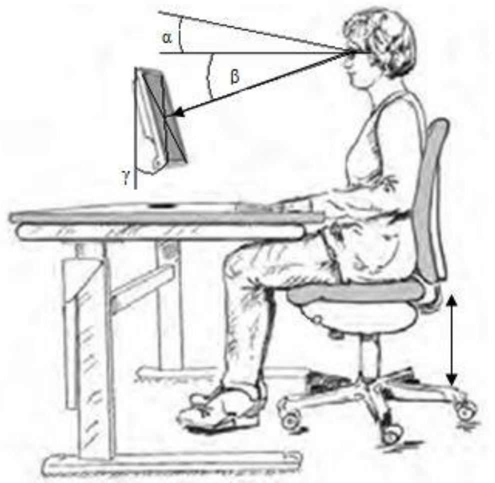


*Figure 1*. Workplace adjustments with respective head inclination (α) and gaze inclination (β). The monitor can be adjusted in inclination (γ) and distance to the eyes; the chair in height among others.

## Experiment 1: Usability Study of "*IfADo* Ergonomic Vision" Website

In the last years, evermore Internet users were seeking health information on the World Wide Web. Particularly, the use of the Internet for web-based interventions is increasing rapidly. These self-management interventions are often designed to provide and disseminate health information for addressing the deficiencies of user’s knowledge, understanding and behavior change. Recent research indicated that individuals using web-based interventions compared to those using non-web-based interventions gathered an improvement in specified knowledge, awareness, and behavior change concerning the respective health variable (Wantland, Portillo, Holzemer, Slaughter, & McGhee, 2004). For the purpose of the present study, a website was created presenting information and a guidance tool for individual ergonomic adjustments of computer workstations. The information was compiled on the basis of recent research in that field (König & Jaschinski, 2009, 2011; Schulz & Jaschinski, 2009; Jaschinski, 2008; Jaschinski, et al., 1998, 1999; Kleinhenz, 2011). The guidance tool consists of two steps: the first step provides information about essential basic settings of the sitting position, table, keyboard and lighting. The second step contains information about the adjustment of the monitor in dependence of the visual aid as the kind of glasses, specifically for presbyopic users, as well as for contact lenses, or no visual aid. In addition to textual explanations, graphics were used for clarification. Since the web-based intervention should be understandable and usable for everyone, a usability study of the website was conducted before the actual intervention started.

### *Methods*

***Respondents.*** Five subjects (3 female, 2 male, mean age = 43.2) participated in the study. Since the purpose of the website was providing information about the individual monitor position dependent on the kind of visual aid, all subjects were representatives in that way that all were mainly working with computers at work. Further, each subject used a different kind of visual aid.

***Procedure.*** Subjects were tested for analyzing the usability of the so-called *IfADo* Ergonomic Vision website. Before the experiment started, each subject adopted a comfortable sitting position in front of a laptop and was explained the tasks. The task was to find the individually optimal monitor position dependent on their visual aid. Afterwards, subjects filled in a questionnaire on their impression of the website. During the task, the subjects were monitored in three ways; the faces were recorded by camera, the performed actions on the screen were followed using a video feed of the subjects screen and an observer was sitting behind the subject taking notes. No time limit was set for conducting the task.

***Results***

In total, four of five subjects completed the task successfully within a period of 3.16 min (SD = 1,45) on average. One subject completed the task incorrectly since he followed in the guidance tool the navigation for another kind of visual aid as he actually used. The five most mentioned characteristics with reference to the website were understandable (5x), useful (5x), modern (4x), attractive (4x), and reliable (4x).

In total, four usability problems were discovered after analyzing the five sessions. On average, subjects came across 2.4 problems, ranging from 1 to 3. A detection matrix is presented in Table 1, showing a summary of all problems, including a short description and an overview which issue came up with each subject at which location. The main problem was that after reaching the information for the recommended monitor position users came to a 'dead end' where they actually expected a way back or forth. Further, the functionality as well as the detection of the guidance tool was unclear. At least, the arrangement and highlighting of the insert text was insufficient so that user could not comprehend the purpose of the website directly.

***Discussion***

The aim of the first study was to determine the usability of the *IfADo* Ergonomic Vision website. The results indicated that the overall impression of the website was positive and the provided information was rated by all subjects as useful and understandable. Based on the observed problems, changes could be made for enhancing the usability of the website. In that way, the ease for using the website and understanding its purpose could be increased. However, the study limitation of the small sample size of only five users has to be considered. Nielsen (2000) suggested that a sample size of five would be adequate for a usability test of a website since in that way 85% of the usability problems could be discovered. For improving the user experience he suggested to do three tests with five users. In the present study, only one test was conducted with five users, suggesting that 85% of the problems were found. Following this rule, 15% of the problems would still be undiscovered. However, finding an

*Table 1*. Detection matrix indicating which subject (S) came up with which usability problem (UP) on the different locations of the website

| | Description | Location | S1 | S2 | S3 | S4 | S5 | Total |
|---|---|---|---|---|---|---|---|---|
| **UP 1** | Missing loop at the 'end' | last pages | **1** | **1** | **1** | **1** | **1** | 5 |
| **UP 2** | Ambiguous functionality of guidance tool | cover page | **1** | **1** | 0 | **1** | 0 | 3 |
| **UP 3** | Missing submenu in upper navigation bar | cover page | 0 | **1** | 0 | 0 | **1** | 2 |
| **UP 4** | Inappropriate text layout | cover page | 0 | 0 | 0 | **1** | **1** | 2 |
| **Total** | per subject | | 2 | 3 | 1 | 3 | 3 | 12 |

adequate sample size in web usability studies is difficult since studies differ in identifying problems and often only a low budget is available (Schmettow, 2012). For future work on the present website, testing of redesigns should be considered.

## Experiment 2: Ergonomic Intervention

The results of the first study indicated that the website provided useful and understandable information. After last modifications the website was applied in the ergonomic intervention study. The aim of the study was to examine the effects of employees' use of the website on self-reported eye strain as well as on musculoskeletal complaints and headache symptoms.

### *Method*

***Study Design.*** The intervention study was conducted in an office section of a North German production company. The study lasted six weeks with three consecutive phases (see Figure 2). In a pre-test, baseline data of each subject were collected by taking measurements of the workplace and providing subjects with a questionnaire on complaints which they filled in one-time at the end of the workday. Then, the intervention instrument in the form of a website was introduced and subjects had the task to adjust their workplaces individually on the basis of the provided information. To investigate the effect of the intervention, workplace measures and questionnaire data were collected one week after the intervention (1st post-test) and again four weeks later (2nd post-test). Finally, a semi-structured interview with each subject was conducted. By means of the interview, information was collected about the motivation for participating, subjects' experience with the conducted workplace adjustment, and for the functioning of the adjustment, e.g. if and what kind of problems occurred.

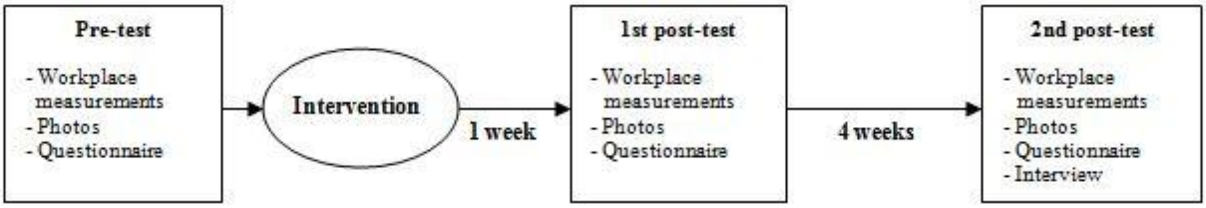


*Figure 2*. The structure of the intervention study with measurement periods and methods.

***Participants***. In total, 32 subjects participated in the study. However, the data of eight subjects could not be used due to incomplete data over the three surveys. The remaining 24 subjects (mean age = 40.7, range: 20-58 years) included 12 females, 15 used either spectacles or contact lenses. Each participant had an own computer workplace and access to the Internet. All signed a written informed consent.

***Intervention***. After the pre-test, each subject got access to the *IfADo* Ergonomic Vision website. As said the website provides a two-step guidance tool about the individual ergonomic adjustment of computer workplaces. The first step contains information about essential basic settings, as e.g. adjustment of the chair, whereas the second step contains information about the adjustment of the monitor in dependence of the visual aid. The subjects had the task to adjust their workplaces individually on the basis of the web-based information. A technician was available if help was needed for adjusting the furniture.

***Measurement***. The measurement consisted of two parts: first, workplace data were collected by taking measurements directly at the computer workplace. The data consisted of table height, depth and width, as well as the monitor height, width and inclination. Second, photos in side-view were taken of each subject during their natural working posture and analyzed subsequently. In that way data could be collected of the inclination of the head, gaze inclination, and the viewing distance from the eyes to the centre of the monitor (Menozzi, et al., 1997).

***Questionnaire***. Subjects filled in a standardized questionnaire on complaints at computer workplaces on a 7-point Likert scale (1=not at all to 7=yes, very much). The questionnaire asked about three different types of complaints: eye strain (seven items), headache symptoms (three items), and musculoskeletal strain (four items). Earlier factor analysis revealed these factors (Jaschinski, 2012a).

***Statistical Analysis*****.** For the present within-subject design a repeated measures analysis of variance (ANOVA) with a significance level of .05 was used. Eta-squared ($\eta^2$) has been used for estimating the effect size (Cohen, 1988). For significant effects, a paired-sample t-test with Bonferroni-Holm correction was conducted. For testing correlations between two variables, Pearson's correlation coefficient was calculated with a significance level of .05; to test whether correlations differed significantly Steiger's z-test was used (Steiger, 1980).

### *Results*

On the basis of the workplace data as well as on the given feedback, it turned out that 23 subjects (96%) had adjusted their computer workplaces. Six of them adjusted the monitor positioning, six altered the chair adjustment, and eleven subjects adjusted both, the monitor as well as the chair. However, one subject neither altered adjustments at the workplace, nor did he report any complaints during the surveys. That subject was excluded from the analysis, leaving 23 subjects (12 females, 11 males, mean age = 40.43) for further analysis.

To determine whether particular workplace and posture adjustments have been changed significantly by the subjects, a repeated measures (ANOVA) was conducted. The results support a main effect of monitor inclination ($F$ (2, 44) = 8.69, $p$ = .001, $\eta^2$ = .283). Compared to the pre-test, the monitor was more tilted backwards one week after the intervention ($t$ (22) = -3.04, $p$ = .006), as well as five weeks later ($t$ (22) = -3.01, $p$ = .006). No significant main effects of head inclination ($F$ (2, 44) = 1.71, ns), gaze inclination ($F$ < 1) and viewing distance ($F$ (2, 44) = 3.17, ns) were found (see Table 2). The ANOVA is appropriate to test main effects, i.e. whether a significant majority changes the ergonomic settings in the same direction. Even without main effects, different subjects may change the settings in different directions; this can be reasonable and helpful since individual physiological disposition can lead to distinct preferred settings in different subjects. Such possible individual effects have been tested with the following correlation analysis. A correlation

*Table 2*. Mean inclinations (in degrees) and distance (in cm) with SD of the different phases. Negative values indicate a more downward inclination.

| | Pre-test ($T_0$) | Post-test 1 ($T_1$) | Post-test 2 ($T_2$) |
|---|---|---|---|
| Monitor inclination | 6.00 (5.52) | 10.07 (7.05) | 9.44 (5.99) |
| Head inclination | 7.02 (6.32) | 5.26 (6.46) | 7.11 (5.07) |
| Gaze inclination | -17.0 (4.78) | -17.44 (5.67) | -17.24 (5.66) |
| Viewing distance | 66.0 (11.12) | 69.97 (10.53) | 70.27 (9.21) |

between the first ($T_1$) and second ($T_2$) post-test indicates that the ergonomic settings remain stable over time after the intervention. This was found for monitor inclination ($r$ = .955, $p$ < .001), gaze inclination ($r$ = .902, $p$ < .001), head inclination ($r$ = .744, $p$ < .001) and viewing distance ($r$ = .809, $p$ < .001). Further, the fact that the correlation between the pre-test ($T_0$) and the first post-test ($T_1$) were smaller than the correlation between the two post-tests ($T_1$ vs. $T_2$) indicates that subjects performed changes in the intervention, partly with different direction of changes so that no significant main effects can be expected. Concerning the monitor inclination, it was found that the correlation $T_0$ vs. $T_1$ ($r$ = .493, $p$ = .017) was smaller than the correlation $T_1$ vs. $T_2$ ($r$ = .955, $p$ < .001). The resulting Δ r = .46 was significant ($Z$ = 4.1, $p$ < .001). Similarly, it was found that for gaze inclination the correlation $T_0$ vs. $T_1$ ($r$ = .545, $p$ = .007) was smaller than the correlation $T_1$ vs. $T_2$ ($r$ = .902, $p$ < .001). The resulting Δ r = .36 was significant ($Z$ = 2.71, $p$ < .001) (see Figure 3). Thus, some of the dependent variables indicate that the ergonomic settings had been changed due to the web-based intervention and that they remained unchanged over the 5-weeks period after the intervention. The difference in correlation for viewing distance (Δ r = .35) and head inclination (Δ r = .25) were statistically not significant.

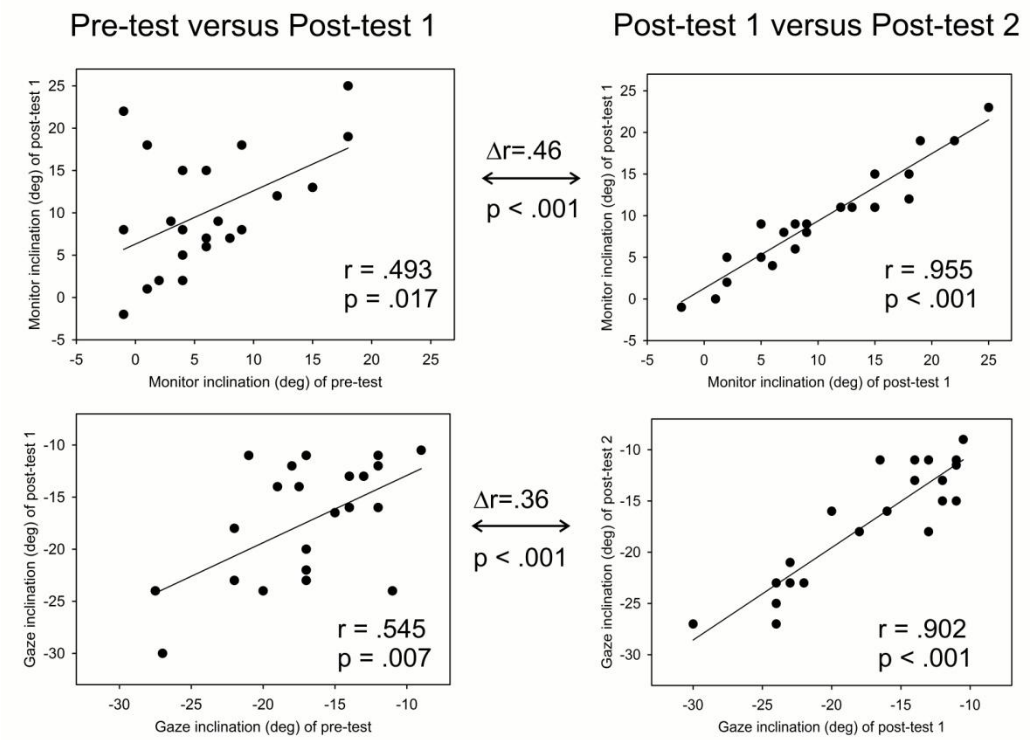


*Figure 3*. Correlation analysis for monitor inclination (*top panels*) and gaze inclination (*bottom panels*). Correlations between pre-test and post-test 1(*left panels*) were significantly correlated, but to a weaker extent than the correlations between post-test 1 and post-test 2 (*right panels*). Regression lines are included.

Before examining the self-reported complaints of the subjects, a confirmatory factor analysis was conducted for assessing to which extent the measured data set fit to the predefined factor model. The model consisted of the three factors eye strain (seven items), headache symptoms (three items) and musculoskeletal complaints (four items). The reliability of the present test scores was high (Cronbach's $\alpha$ = .916). Further, a varimax rotation supported the existing three factor solution, only one item of the factor eye strain had a loading below .1; however, an exclusion would not enhance the reliability (see Appendix).

To determine whether work-related complaints were reduced due to the intervention, a repeated measures ANOVA was conducted. In the pre-test, 19 subjects reported eye strain (83%), 17 subjects reported headache symptoms (74%) and 22 subjects reported musculoskeletal complaints (96%). The results support a main effect of reported musculoskeletal complaints ($F$ (2, 44) = 3.50, $p$ = .039, $\eta^2$ = .137). As expected, a planned comparison showed that subjects reported less musculoskeletal complaints one week after the intervention ($t$ (22) = 2.57, $p$ = .009, one-tailed) as well as five weeks later ($t$ (22) = 2.06, $p$ = .026, one-tailed), each in comparison with the pre-test. Further, a main effect of reported headache symptoms was found ($F$ (2, 44) = 4.13, $p$ = .043, $\eta^2$ = .158). As expected, subjects reported less headache symptoms one week after the intervention ($t$ (22) = 2.23, $p$ = .018, one-tailed) as well as five weeks after the intervention ($t$ (22) = 1.99, $p$ = .030, one-tailed) each compared to the pre-test. No significant effect of reported eye strain was found ($F$ (2, 44) = 1.34, ns). However, in general subjects reported fewer complaints in the post-tests than in the pre-test (see Figure 4).

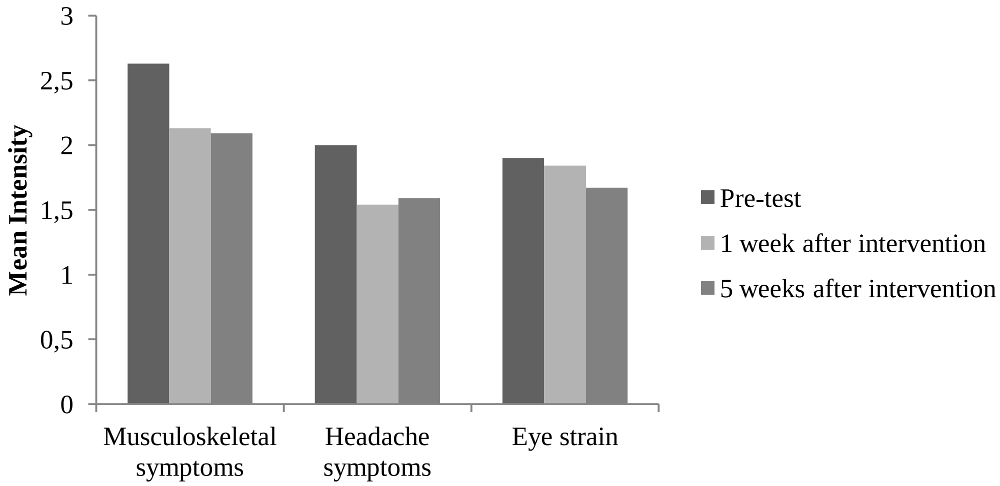


*Figure 4.* Mean intensity of the self-reported complaints. Subjects reported after the intervention less complaints than before in the pre-test.

Further, it was examined whether changes in reported complaints are related to implemented workplace adjustments. The 17 subjects who had adjusted their chairs reported a significant mean reduction of musculoskeletal complaints in the first post-test ($t$ (21) = -2.38, $p$ = .027); such an effect was not found in those six subjects who did not adjust their chairs. As presented in Figure 5, significant correlations were found between the difference of viewing distance and the difference of musculoskeletal complaints of the first ($r$ = .430, $p$ = .041) and second post-test ($r$ = .448, $p$ = .032). Subjects who increased the viewing distance reported more musculoskeletal complaints in each post-test. Further, a significant correlation was found between the difference of gaze inclination and the difference of eye strain of the first post-test ($r$ = -.429, $p$ = .026). Subjects who increased the gaze inclination (lowered their gaze) reported less visual complaints. No significant correlation was found between the change in head inclination and self-reported musculoskeletal complaints in the first ($r$ = -.131, ns) and second ($r$ = .158, ns) post-test.

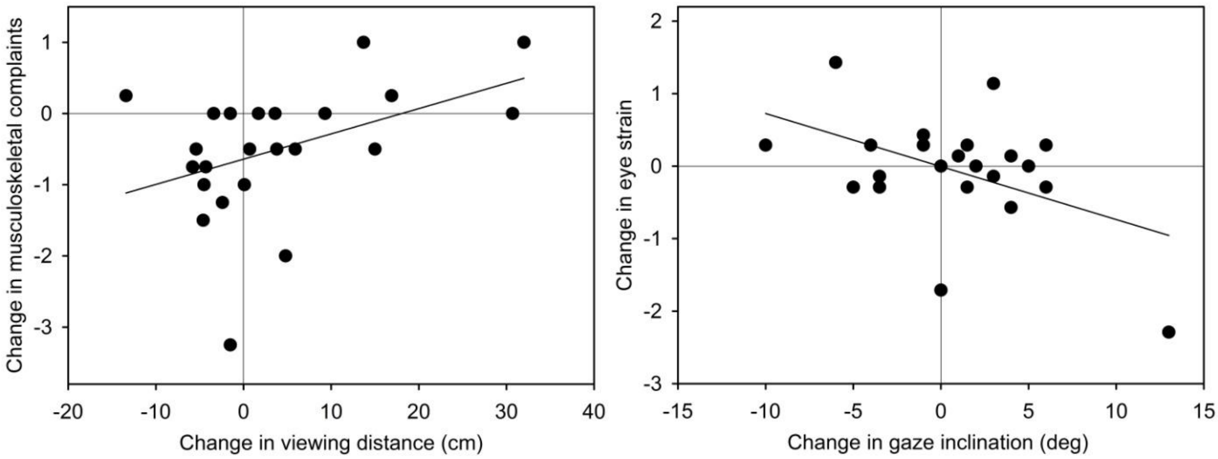


*Figure 5*. *Left*: Change in musculoskeletal complaints in relation to change in viewing distance after the first post-test. Subjects who strongly increased the viewing distance tended to report afterwards more musculoskeletal complaints. *Right*: Change in gaze inclination in relation to change in eye strain after the first post-test. Subjects who increased the inclination relative to horizontal, thus lowered the gaze to the monitor reported afterwards averagely about less eye strain.

### *Discussion*

The aim of the present study was to examine the effect of a web-based office ergonomic intervention on behavioral changes and on self-reported complaints of employees. For this purpose, an intervention with three consecutive test phases was conducted in an office department. First, baseline data of self-reported complaints and workplace data were collected in the pre-test (phase 1). Next, the website was introduced, followed by employees' adjustments of the workplaces on their own, on the basis of the web-based information. After the employees worked one week (first post-test, phase 2) and four more weeks (second post-test, phase 3) with this setting data on workplace data and self-reported complaints were collected again. It was expected that subjects change their behavior by adjusting their computer workplaces. Further, it was assumed that self-reported musculoskeletal and visual complaints as well as headache symptoms will be reduced after the intervention.

The results indicate that all subjects except one adjusted their computer workplaces after the intervention: subjects altered either the monitor, the chair or both. As subjects reported, their tables were not adjustable due to missing regulation possibilities. The main adjustments were done directly after the intervention. The changes in monitor as well as in gaze inclination retained unchanged throughout the four weeks after the intervention. Some individual changes in viewing distance and head inclination were noticeable probably due to differences in natural posture behavior. However, it can be concluded that employees adjusted their workplaces ergonomically after the web-based intervention and retained it as their individual preferred position. Based on these findings, it can be concluded that the website served as a helpful tool. Employees changed their behavior and used their workplace consciously under own control.

Further, all subjects except one reported work-related complaints in the pre-test, thus they had either headache symptoms and/or musculoskeletal complaints and/or eye strain. The results of the present study indicate reductions of headache symptoms and musculoskeletal complaints due to the web-based intervention. Further, no main effect of eye strain was found, although subjects reported less eye strain after the intervention. It is remarkable that musculoskeletal complaints were higher than eye strain and headache symptoms. The mean effect of this improvement subtended 0.5 on a 7-point Likert scale and was statistically significant. This effect may be practically relevant when compared with the following study: Jaschinski (2012b) confirmed earlier findings of Krueger (1989) that work-related complaints are increasing with longer working hours: employees working less than five hours a day at computer monitors reported less complaints compared to employees working more than five hours a day at monitors. The difference in reported musculoskeletal complaints subtended 0.5 on a 6-point Likert scale. This effect of working hours at computer monitors can be taken as practically relevant; thus, this may also be concluded for the effect of the present intervention of similar amount. Concerning the reduced musculoskeletal complaints, a significant effect with chair adjustments was found. Subjects who changed chair adjustments reported less musculoskeletal complaints after the intervention than before. This result corresponds to earlier findings that an ergonomic chair position can lead to fewer musculoskeletal complaints (Amick et al., 2003; Groenesteijn et al., 2009). Since in the present study no direct chair measurements were taken, it remains unclear which kind of chair adjustments were related to the reduction in complaints. However, it could be assumed that subjects followed the web-based information and adjusted the seat height for right-angled legs, the armrests in height resulting in a right-angled arm position, and/or the backrest of the seat for supporting the back. These adjustments are physiological convenient for preventing and reducing musculoskeletal complaints since the spine gets relieved and less forced postured result in relaxed muscles (Kleinhenz, 2011).

Moreover, each subject preferred an individual viewing distance to the monitor. This finding is in line with earlier results of Jaschinski et al. (1999) who pointed out that individuals differ reliably in comfortable screen positions relative to the eyes. However, contrary to earlier findings, subjects who increased the distance between screen and eyes tended to more musculoskeletal complaints after the present intervention. However, those who did not change the viewing distance very much (within ± 8cm), showed partly a reduction of musculoskeletal complaints. This could be a benefit of having adjusted the chair. Five subjects increased the viewing distance by more than 10cm. This subgroup tended to report stronger musculoskeletal complaints after the intervention. A possible explanation for this finding could be that larger viewing distances lead to higher gaze angles, as long as the screen is shifted at a constant height above table plane. As subjects reported, some monitors could only be adjustable in height within a limited range. Further, the head inclination changes with increasing distance. Although no significant correlation was found between head inclination and the viewing distance, some subjects tilted their neck back with increasing distance between eye and monitor. This forced posture with higher head inclination would result in musculoskeletal complaints. The web-based guidance tool recommended placing the monitor at a distance until having clear vision, for less eye strain and less visual discomfort (Jaschinski et al., 1999). However, no recommendations with reference to comfortable head positions were given.

Further, results document a main effect of monitor inclination. Thus, subjects inclined their monitor significantly more backwards after the intervention. A correlation was found between changes in gaze inclination and self-reported eye strain: subjects who lowered their gaze to a more downward direction reported afterwards less eye strain, although no main effect of eye strain was found. This is consistent with earlier findings that a vertical gaze on the screen and a gaze inclination within a range of -5 to -20° downwards induce less eye strain (Jaschinski et al., 1999; Lie & Fostervold, 1995) and result in minimum perceived exertion of the eyes (Menozzi et al., 1994). The results correspond with the physiological function of the visual system, that the eyes at rest are declined relative to horizontal, resulting in less forced postures and exertions for the eyes (Menozzi et al., 1994). Further, this finding is of practical relevance since Schmidtke (1991) indicated in his study that the number of reading errors increased the more the gaze direction deviated from a perpendicular orientation relative to the monitor. Thus, it can be suggested that due to the adjustments on the basis of the web-based intervention also the quality of work at the monitor increased.

Contrary to expectations, no significant effect of head inclination in relation to a reduction of musculoskeletal complaints was found. Based on earlier findings (Kleinhenz, 2011; Lie & Fostervold, 1995) it was assumed that a lowered head inclination would result in reduced musculoskeletal complaints. In relation to workplace adjustments, the head inclination would be lowered when the monitor would have a low position on the table. A possible explanation for the present finding could be that subjects did not change the height of the monitor significantly. Some subjects reported after the intervention that the monitor could only be adjusted within a limited range. Moreover, other subjects could have had already a comfortable head position before the intervention and did not change it significantly.

Further, the present study was a field study, thus the external validity was high since the study was conducted at the real workplaces of the subjects. Subjects were randomly chosen, thus everyone working in the office department could sign in for the study. This enhances the external validity since findings could be generalizable to other real world office workers and settings. However, a major limitation of the present study is the lack of a control group, resulting in a reduced internal validity.  Thus, alternative explanations for the findings such as the Hawthorne effect have to be considered. This means that the effects could have been occurred because employees changed their behavior due to pure observation. In a typical

Hawthorne effect, one would expect a strong effect directly after the intervention and a decline of the effect at later times. However, in the present study it was found that the reduction of complaints persisted over four weeks. Further, subjects maintained the ergonomic settings over those four weeks, which confirmed a sustained effect that they found these changes of the intervention useful. However, another follow-up measure after a few months should be envisaged since a conscious approach with ergonomic behavior at the workplace should last beyond the study and without having a feeling of observation. Further, future studies on office ergonomic interventions should include a control group.

Moreover, as earlier studies pointed out (MacDonald et al., 2001; Laitinen, et al., 1998), psychosocial factors such as stress at work can have an impact on health at work, especially with reference to musculoskeletal complaints. Future studies on office ergonomics should include the measurement of psychosocial factors for assessing more impact variables on the prevention and reduction of work-related complaints.

As a conclusion, the present study indicates the relevance of office ergonomic interventions. It is essential that employees are conscious of their dynamic workplaces and that already a few adjustments can result in reduced complaints. For this purpose, the established website presenting the guidance tool was convenient. In that way, employees had independent control over the changes of their workplaces, including a conscious approach. Sometimes employees do not accept the expert's suggestion for ergonomic changes; rather, they tend to go back to their habitual workplace settings. However, in the present study, the changes that employees had performed themselves have been kept constant after the web-based intervention. Thus, the website is a cost-effective and simple alternative to expensive and time-consuming expert training conducted so far in offices. It can be used as prevention as well as a treatment of work-related complaints. After the present intervention, self-reported musculoskeletal as well as headache symptoms were reduced. Particularly, chair adjustments led to a reduction of musculoskeletal symptoms, indicating the usefulness of a convenient sitting position at a computer for office workers. Moreover, a monitor inclination more backwards led to a more tilted gaze inclination, resulting in a reduction of eye strain, which suggests the importance of the monitor position relative to the eyes. The *IfADo* Ergonomic Vision website may be used as a tool in further ergonomic research and application to extend the present findings.

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# Appendix

*Table 1*. Results of the confirmatory factor analysis including the reliability coefficient α of the present test scores.

| Factor | Items | α | Factor loading |
|---|---|---|---|
| Eye strain | I have difficulties in seeing. | .785 | .574 |
| | I have a feeling of heavy eyelids. | | < .1 |
| | My eyes are hurting. | | .144 |
| | I have tears in my eyes. | | .937 |
| | I have burning eyes. | | .113 |
| | I have a strange feeling around the eyes. | | .108 |
| | I have itching eyes. | | .674 |
| Headache symptoms | I feel dumb. | .711 | .738 |
| | I feel dizzy. | | .730 |
| | I have a headache. | | .278 |
| Musculoskeletal complaints | I have pain my arms. | .905 | .559 |
| | I have pain in my neck. | | .962 |
| | I have pain in my back. | | .776 |
| | I have pain in my shoulders. | | .774 |