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Web-based office ergonomics intervention on work-related complaints: a field study

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The aim of this study was a proof of concept to examine the effects of a web-based office ergonomics intervention on subjects' individual workplace adjustments. An intervention study was conducted with 24 office workers lasting 6 weeks with three consecutive phases (before, 1 and 5 weeks after the intervention). Employees used a purpose-made website for adjusting their computer workplaces without any personal support of ergonomics experts. Workplace measurements were taken directly on site and by analysing photos taken of the employee. Self-reported complaints were assessed by filling in a questionnaire. It was found that 96% of the employees changed their workplaces on their own and retained them mostly unchanged after the intervention. Furthermore, self-reported musculoskeletal complaints and headache symptoms decreased significantly after the intervention. These findings suggest an improvement of workplace conditions so that cost-effective ergonomic web-based interventions appear promising in further research and application.

Practitioner Summary: A field study was conducted using for the first time a website as an intervention tool in offices. Employees used it independently without personal expert training. Results indicated that employees could improve their computer workplace situation after using the website.

Keywords: computer workplace; eyestrain; musculoskeletal complaints; training; e-learning

1. Introduction

1.1. Complaints at computer work and the underlying individual mechanisms

During the last years, the amount of computer use at work has increased rapidly. In the European Union, 50% of women and 45% of men work on computers every day (Eurofound 2007). Furthermore, occupational illnesses such as musculoskeletal disorders and psychosocial stress increased in the last years (BAuA 2011). A lack of effective protection for ensuring health and safety at work can result in absenteeism, occupational illness and permanent occupational disability. 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 (Lundberg and Johansson 2000). However, in the last years, several studies indicated an association between computer work and occupational illnesses such as musculoskeletal disorders (Fang et al. 2007; Levanon et al. 2012; Robertson 2007; Taieb-Maimon et al. 2012), eye strain (Aarås, Horgen, and Helland 2007; Jainta and Jaschinski 2002; Rempel et al. 2007; Robertson, Ciriello, and Garabet 2013; Rosenfield 2011) and psychosocial stress (Gilbert-Ouimet et al. 2011; Huang, Robertson, and Chang 2004). The causes for such work-related complaints are often a combination of physical and psychosocial factors (Bongers et al. 2006; Johnston et al. 2010). Especially, repetitive work and a static posture over a longer period of time at a computer can induce musculoskeletal and visual complaints (Wahlström 2005). 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. Affected persons complain about symptoms ranging from discomfort and pain to reduced bodily function and invalidity (EU-OSHA 2008). Another work-related complaint in association with computer work is eye strain including burning eyes, flickering, fatigue and blurred vision. It is emphasised that ergonomically optimal offices can have a positive impact on musculoskeletal and visual strain (Helland et al. 2011). Especially, the position of the computer monitor relative to the eyes can influence eye strain (Jaschinski, Heuer, and Kylian 1998; Rempel et al. 2007). Furthermore, the kind of eyewear has an impact on the appropriate positioning of computer screens, particularly for presbyopic users (Allie et al. 2010). Moreover, the right chair adjustment can also reduce visual symptoms (Amick et al. 2012; Menéndez et al. 2012). Thus, the ergonomics design and adjustment of a computer workplace should be based on anthropometric measures and physiological mechanisms as each human has an individual length of arms, legs and upper body as well as individual characteristics of the visual system (Jaschinski and Heuer 2004). This principle of ergonomics design appears to go straightforward, but it is difficult to realise in practical procedures. The human physiological system is complex enough to comprise different

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mechanisms in which individuals differ considerably so that a standard workplace setting does not provide the optimal condition for all users. Instead, individual solutions are required (Jaschinski, Heuer, and Kylian 1999).

1.2. Ergonomics workplace adjustments: from personal to web-based intervention

For achieving ergonomically convenient conditions concerning the musculoskeletal and the visual system at computer workplaces, the provision of adjustable office furniture is essential. Particularly, ergonomics adjustments of office chairs (Amick et al. 2012; Corlett 2006; Groenesteijn et al. 2009; Menéndez et al. 2012), table height and monitor positioning (Jaschinski, Heuer, and Kylian 1998, 1999; Rempel et al. 2007) in dependence of individual physiological differences have shown positive effects on a prevention and reduction of work-related complaints. However, providing adjustable office furniture alone is often not sufficient. Recent studies indicated that the awareness of office ergonomics has to be raised by training the employees (Robertson, Ciriello, and Garabet 2013). Occupational health and safety training can affect employees' behaviour at work positively (Robson et al. 2012). By means of ergonomics interventions, work-related disorders in an office environment can be prevented or reduced (Kennedy et al. 2010; Ketola et al. 2002; Levanon et al. 2012). A successfully implemented office ergonomics intervention can result in an increased ability of the employees to change their work environment, leading to reduced work-related complaints and an improved effectiveness. Giving employees control over their physical work environment can enhance their physical health and performance (Huang, Robertson, and Chang 2004). In previous studies in that field, a common intervention form was a personal office ergonomics training of the employees (Robertson 2007; Gilbert-Ouimet et al. 2011). Using this method, experts train the employees in groups at a specific location, normally for several hours. In general, employees listen to an expert's lecture followed by an adjustment of their workplaces. In dependence of the expenditures, it is advisable to estimate the upcoming cost–benefit ratio (Menozzi et al. 1999). However, personal expert training can be time-consuming and also cost-intensive because, for example, materials and the expert's salary have to be paid.

An applicable alternative to personal expert training can be the use of an e-learning-based method. The use of computer network technology for delivering training is increasing as it has many advantages. By means of e-learning, a large number of employees can be trained in a short and flexible period of time according to their schedule. Furthermore, usually it can be used repeatedly on the own computer which obviates travel costs and time as well as a trainer's salary (Gunasekaran, McNeil, and Saul 2002; Welsh et al. 2003). Concerning the effectiveness of e-learning, research has indicated that users gain a sense of control (Ruiz, Mintzer, and Leipzig 2006). The underlying behavioural intention of the learners and the perceived usefulness positively affect e-learning effectiveness (Liaw 2008). The enhancement in knowledge is as effective as traditional trainers-led methods (Ruiz, Mintzer, and Leipzig 2006).

The present study availed the benefits of the e-learning method and used an alternative approach for providing information on office ergonomics than the traditional expert training. For this purpose, a web-based intervention was established in order to have employees adjust the workplaces without personal expert contact. 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 behaviour change. Research in this field indicated that individuals using web-based interventions gathered an improvement in specified knowledge, awareness and behaviour change concerning the respective health variable compared with those using non-web-based interventions (Wantland et al. 2004).

1.3. Aim

In this field study, the effects of a web-based office ergonomics intervention on subjects' individual implementations of workplace adjustments were examined. On the basis of previous findings, it is presumed that the intervention leads to ergonomics changes so that subjects will adjust their workplaces which will remain rather unchanged after the intervention. To describe the ergonomics conditions, the following four variables were measured: monitor inclination, viewing distance, head inclination and gaze inclination. Moreover, self-reported complaints are supposed to be reduced after the intervention. For this purpose, three dependent variables, musculoskeletal complaints, headache complaints and eye strain, were used. Based on previous findings, it is expected that chair adjustments will result in lower self-reported musculoskeletal complaints (Robertson et al. 2009). Furthermore, it is expected that a lowered and more perpendicular gaze on the screen will result in lower eye strain (Jaschinski, Heuer, and Kylian 1999; Lie and Fostervold 1995).

2. Method

2.1. Study design

The intervention study was a quasi-experiment using a pre–post test design without a control group (Shadish, Cook, and Campbell 2002). It was conducted in an office section of a North German company which produces flexible monitor support arms among others. These mountings were installed in the present offices and allowed for a flexible monitor positioning. In total, the study lasted 6 weeks with three consecutive phases. In a pre-test (T0), baseline data of each subject were collected by taking measurements of the workplace and providing subjects with an online 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. Subjects had the task to adjust their workplaces individually on the basis of the provided information. To investigate the effects of the intervention, workplace measures and questionnaire data were collected 1 week after the intervention (first post-test/T1) and again 4 weeks later (second post-test/T2). The only personal help was provided by a technician of the company, if help was necessary for adjusting the furniture. The participants were free to use as much time for using the website as they found helpful; this time was not measured as the experimenters were not involved in this period of the study.

2.2. Subjects

Twenty-four subjects (12 females, mean age = 40.7, range: 20–58 years) participated in the study. Fifteen used either spectacles or contact lenses, and all were tested to reach a visual acuity of at least 0.8 in far vision and near vision. Each participant had an own computer workplace and access to the Internet. All signed a written informed consent. The procedures applied were in accordance with the ethical standards of the Helsinki declaration.

2.3. Intervention

The purpose of the intervention was that subjects learn the implementation of individual workplace adjustments by using a web-based guidance tool on their own. After the pre-test, each subject got access to the intervention tool: the so-called IfADo Ergonomic Vision website. The website provided a two-step guidance tool about individual ergonomics adjustments of computer workplaces. The first step contained information about essential basic settings of the sitting position, table, keyboard and lighting. The second step contained information about the adjustment of the monitor in dependence of the kind of eyewear. For non-presbyopic users, a 5-day test procedure was recommended, placing the monitor each day in a different position (low and near, at eye level and near; low and distant, at eye level and distant). At the last day, they were advised to adjust their screen individually to their preferred position (Jaschinski, Heuer, and Kylian 1999). Presbyopic subjects using spectacles for computer vision found recommendations depending on the type of glasses that they used as their fields of clear vision at near distances are limited. In addition to textual explanations, graphics were used for clarification. As the web-based intervention should be understandable and usable for everyone, a usability study of the website was conducted before the actual intervention started.

2.4. Measurement

The measurements 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 height and width of the monitor and its inclination relative to vertical. Second, photos in side view were taken of each subject during their natural working posture and subsequent geometrical analyses (Figure 1). In this way, data of gaze inclination (line from the canthus at the eye to the centre of the screen, relative to horizontal) and viewing distance (from the canthus at the eye to the centre of the monitor) were collected. Furthermore, head inclination was measured and reported as eye–ear line (line from the canthus at the eye to the tragus at the ear, relative to horizontal). This eye–ear line is – on average – about 11° above the Frankfurt plane (from the orbitale to the porion).The Frankfurt plane is close to horizontal with an upright head posture (Menozzi et al. 1994).

2.5. Questionnaire

In each phase, subjects filled in a questionnaire on complaints at computer workplaces on a 7-point Likert scale (1 = not at all to 7 = yes, very much) at the end of the workday. It asked about three different types of complaints: eye strain (seven items), headache symptoms (three items) and musculoskeletal strain (four items) (Table 1). These scores had been successfully used in previous studies (Jaschinski, Heuer, Kylian 1998, 1999). A recent further study (Jaschinski et al. submitted) reports results of a confirmatory factor analysis on these items: it was found that these three scores of strain resulted from the observed structure of inter-correlations between the items. When each of these scores were scaled based on the factor loading, the results were highly correlated ($r = 0.95$ or higher) with the simple average across each type of complaints. Therefore, the average across the actual number of items was taken as scores of eye strain, headache symptoms and musculoskeletal strain. This procedure was confirmed by a factor analysis.

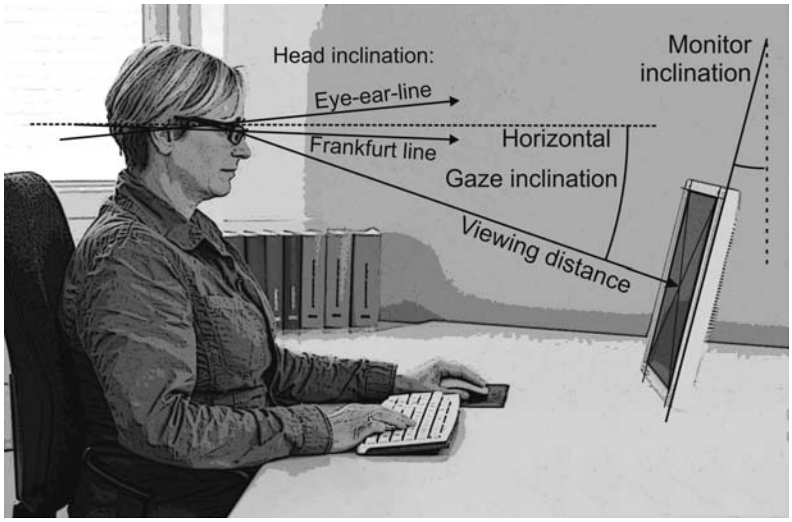

Figure 1. Photograph at a computer workplace with included lines of reference for geometrical analyses of the following ergonomics workplace parameters: viewing distance (from the eye to the centre of the monitor), gaze inclination angle (direction of gaze from eye to the screen centre relative to horizontal), monitor inclination (direction of the monitor plane relative to vertical) and head inclination (measured as eye–ear line relative to horizontal). The Frankfurt line of head inclination is – on average – 11° below the eye–ear line (see text for details). This photograph illustrates the ergonomic measures and does not show the actual office conditions where different types of rather flexible monitor stands and support arms were installed.

Table 1. Items and scale on the questionnaire asking about work-related complaints.

Eye strain
1. I have difficulties in seeing.
2. My eye lids are heavy.
3. I feel eye strain.
4. I have burning eyes.
5. I have a strange feeling around the eyes.
6. I have itching eyes.
Headache symptoms
1. I feel dumb.
2. I feel dizzy.
3. I have a headache.
Musculoskeletal strain
1. I have pain in my arms.
2. I have pain in my neck.
3. I have pain in my back.
4. I have pain in my shoulders.

Note: The items had the following 7–point scale: not at all = 1 2 3 4 5 6 7 = yes, very much.

2.6. Statistical analysis

For the present within-subject design, a repeated measures analysis of variance (ANOVA) with a significance level of 0.05 was used. For not normally distributed data, a Wilcoxon signed-ranked test was conducted. Eta-squared (η^2) has been used for estimating the effect size (Cohen 1988). A Levene's test was conducted to examine the homogeneity of variances of differences between the phases. For testing correlations between two variables, Pearson's correlation coefficient was calculated with a significance level of 0.05; to test whether correlations differed significantly, Steiger's *Z*-test was used (Steiger 1980).

3. Results

3.1. Analysis of changes in ergonomics settings

On the basis of the workplace data and on the given feedback, it turned out that 23 of the 24 subjects (96%) had adjusted their computer workplaces. Wherein 6 of them adjusted the monitor positioning, 6 altered the chair adjustment and 11

Table 2. Mean inclinations (in degrees) and distance (in cm) with SD of the three phases.

	Pre-test (T0)			Post-test 1 (T1)			Post-test 2 (T2)		
	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
Monitor inclination	− 7.70	6.37	− 23 to − 1	− 10.39	6.42	− 25 to 2	− 10.70	6.94	− 25 to 3
Head inclination	8.52	7.22	− 5 to 24	6.91	7.00	− 7 to 19	7.96	5.45	− 3 to 19
Gaze inclination	− 17.13	4.96	− 28 to − 8	− 17.78	5.25	− 29 to − 10	− 17.04	4.97	− 26 to − 9
Viewing distance	67.32	11.18	50.8–91.5	71.91	11.87	52.7–99.2	71.60	14.51	52.1–119.5

Note: Negative values indicate a more backward inclination of the monitor plane and a downward inclination of the head (eye–ear line) or gaze direction (line from eye to centre of the monitor).

subjects adjusted both the monitor and the chair. However, one subject neither altered adjustments at the workplace nor did he report any complaints during the surveys. This subject was excluded, leaving 23 subjects (12 females, 11 males, mean age = 40.43) for further analysis.

Table 2 gives an overview of the geometric ergonomics settings in the course of the study. First, it was determined which particular workplace and posture adjustments have been changed significantly by the subjects during the intervention. For testing possible group mean effects, a repeated-measures ANOVA was conducted. The results supported a main effect of monitor inclination, $F(2, 44) = 4.57, p = 0.036, \eta^2 = 0.17$. As expected, a planned comparison showed that compared to the pre-test ($M = -7.70$, SD = 6.37), the monitor was tilted more backwards 1 week after the intervention ($M = -10.39$, SD = 6.42) [$F(1, 22) = 4.70, p = 0.041$] and 5 weeks after the intervention ($M = -10.70$, SD = 6.94) [$F(1, 22) = 4.98$, $p = 0.036$]. This means that participants changed the angle of monitor inclination towards the angle of gaze inclination (− 17°), i.e. they reduced the deviation of gaze from a perpendicular direction relative to the screen surface. No significant main effects of head inclination [$F < 1$], gaze inclination [$F < 1$] and viewing distance [$F(2, 44) = 2.43$, ns] were found.

3.2. *Individual effects*

The ANOVA is appropriate to test main effects, i.e. whether a significant majority of subjects changes the ergonomics settings in the same direction. Even without main effects, different subjects may change the settings in different directions; this can be reasonable and helpful as individual physiological dispositions can lead to distinct preferred settings in different subjects (Jaschinski, Heuer, and Kylian 1998, 1999). Such possible individual effects have been tested with the following three types of analyses.

3.2.1. *Geometric analysis of monitor position relative to the eyes*

To determine the extent of workplace changes during the intervention and whether these conditions remained unchanged after it, a geometric analysis on the basis of the workplace measurements was conducted. For this purpose, the monitor position relative to the eyes was analysed using the variables viewing distance and gaze inclination. To illustrate the workplace changes between the phases, vector plots were compiled. One vector plot showed the changes from the pre-test to directly after the intervention (T0–T1) and a second vector plot showed the changes across the 4 weeks after the intervention (T1–T2) (Figure 2). A comparison showed that the vector length of the changes T0–T1 ($M = 10.17$, SD = 8.59) was significantly larger than the vector length of the changes T1–T2 ($M = 7.43$, SD = 8.54) [$W = -2.62, p = 0.009$]. This analysis indicated that the main workplace adjustments implemented directly after the intervention were generally larger than the changes that occurred in the4-week period after it. Due to normal variability and a dynamic way of working, some changes in the time after the intervention were expected. Despite this general pattern of results, two subjects showed rather larger changes from T1 to T2, leading to a non-normally distributed vector length, so that a Wilcoxon test was used.

3.2.2. *Analysis of variability of individual differences*

As explained, it can be physiologically reasonable that different subjects may change an ergonomics setting in distinct directions due to the intervention. Thus, the distribution of individual changes may be considered, i.e. the inter-individual variability of differences from T0 to T1. This variability can be characterised by its standard deviation. The standard deviation is expected to be large if large ergonomics changes have been made due to the intervention. Furthermore, it is expected that after the intervention, the ergonomics settings remain mostly stable, if the new settings are accepted and maintained. Therefore, it was hypothesised that the variance of the individual differences between T1 and T2 is smaller than that between T0 and T1, as the latter includes the variability due to the intervention. A Levene's test was used to examine

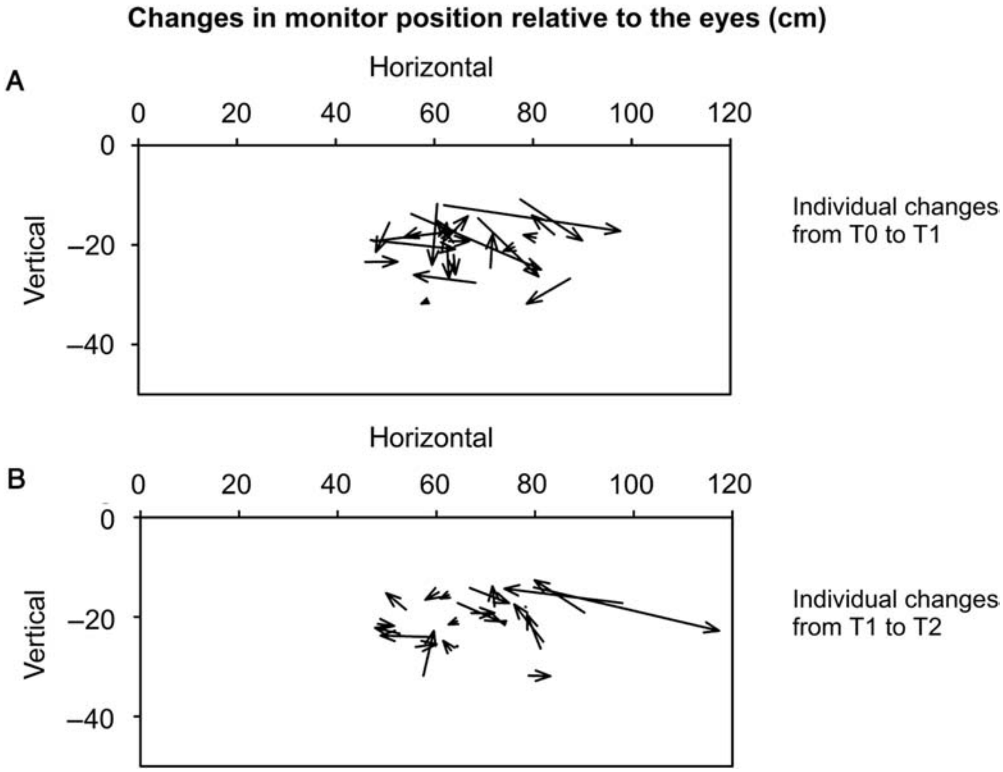

Figure 2. Changes in monitor position relative to the eyes in the course of the study, displayed in workplace coordinates with the eye at the origin of each plot. A single vector is shown for each participant and illustrates how the position of the monitor relative to the eye has been changed after participants adjusted their chair and monitor. The vectors in (a) show the shifts in monitor position from before (T0) to directly after the intervention (T1), while the vectors in (b) show the shifts in monitor position in the course of the after-intervention phase, i.e. from directly after the intervention (T1) to 4 weeks later (T2).

the homogeneity of variances of the differences between T0 and T1 with the differences between T1 and T2. The test indicated that the variance of monitor inclination was significantly larger between T0 and T1 (SD = 5.97) than that between T1 and T2 (SD = 2.27) [$F = 7.62$, $p = 0.008$]. The same effect was found for gaze inclination (T0–T1: SD = 4.57; T1–T2: SD = 2.53) [$F = 9.03$, $p = 0.004$] and head inclination (T0–T1: SD = 7.70; T1–T2: SD = 4.70) [$F = 4.44$, $p = 0.041$]. Thus, it can be concluded that for these parameters, the individual changes due to the intervention were larger than the changes that have been found between the two post-tests.

3.2.3. Correlation analysis

The supposed individual ergonomics changes in different directions can also be statistically tested by analysing correlations. Therefore, it was hypothesised that correlations between T1 and T2 were particularly high as these two settings were expected to be similar, i.e. unchanged after the intervention. However, due to intervention effects, correlations between the settings T0 and T1 were expected to be smaller than those between T1 and T2 due to intervention effects.

This expected pattern of result was found for monitor inclination: the correlation T0 vs. T1 ($r = 0.57$, $p = 0.005$) was smaller than the correlation T1 vs. T2 ($r = 0.95$, $p < 0.001$). The resulting $\Delta r = 0.38$ was significant ($Z = 4.93$, $p < 0.001$). Furthermore, a significant Δr was found for gaze inclination and head inclination (Table 3). Thus, the dependent variables, monitor inclination, gaze inclination and head inclination, indicated that ergonomics settings had been changed due to the web-based intervention and that they remained unchanged over the 4-week period after it. The corresponding difference in correlation coefficients for viewing distance ($\Delta r = 0.16$) was statistically not significant (Table 3).

3.3. Analysis of complaints

In the pre-test, 19 subjects reported eye strain (83%), 17 subjects reported headache symptoms (74%) and 22 subjects reported musculoskeletal complaints (96%). The intensity in complaints is shown in Figure 3. To determine whether

Table 3. Correlation coefficients of the workplace measures for different phases, with Steiger's Z values testing whether the correlations differ significantly.

	T0–T1		T1–T2				
	r	p	r	p	Δr	Z	p
Monitor inclination	0.57	0.005	0.95	<0.001	0.38	4.93	<0.001
Head inclination	0.47	0.024	0.80	<0.001	0.33	2.57	0.005
Gaze inclination	0.60	0.002	0.88	<0.001	0.28	2.47	0.007
Viewing distance	0.51	0.013	0.67	<0.001	0.16	1.16	0.124

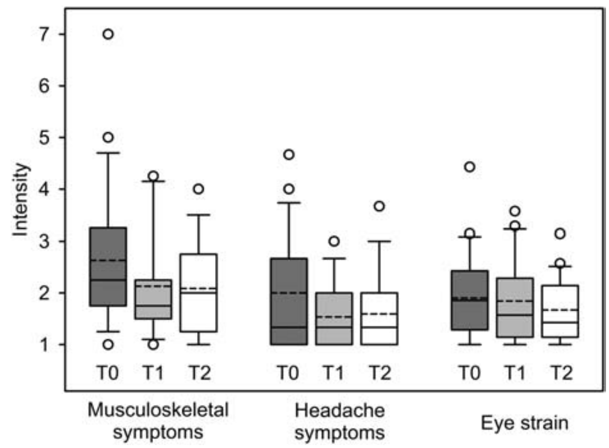

Figure 3. Box plots of the scores of musculoskeletal strain, headache symptoms and eye strain in the course of the three test phases: T0 before the intervention, T1 directly after the intervention and T2 after four additional weeks. The drawn line within a box indicates the median and the dotted line indicates the mean value.

work-related complaints were reduced after the intervention, a repeated-measures ANOVA was conducted. The results support a main effect of reported musculoskeletal complaints [F (2, 44) = 3.50, $p = 0.039$, $\eta^2 = 0.14$]. As expected, a planned comparison showed that subjects reported less musculoskeletal complaints after the intervention ($M = 2.13$, SD = 0.10) than in the pre-test ($M = 2.63$, SD = 1.42) [F (1, 22) = 6.61, $p = 0.017$, $\eta^2 = 0.23$]. Furthermore, a main effect of reported headache symptoms was found [F (2, 44) = 4.13, $p = 0.043$, $\eta^2 = 0.16$]. As expected, subjects reported less headache symptoms after the intervention ($M = 1.54$, SD = 0.67), than in the pre-test ($M = 2.00$, SD = 1.05), [F (1, 22) = 4.96, $p = 0.036$, $\eta^2 = 0.18$]. No significant effect of reported eye strain was found [F (2, 44) = 1.34, ns, $\eta^2 = 0.06$]. However, in general, subjects reported fewer complaints in the post-tests than in the pre-test.

3.4. Test of relations between changes in ergonomics settings and complaints

Furthermore, it was examined whether changes in reported complaints are related to implemented workplace adjustments. Concerning the conducted chair adjustments, a significant difference in change of musculoskeletal complaints was found between those who adjusted the chairs and those who did not [t (21) = −2.38, $p = 0.027$)]. The 17 subjects who had adjusted their chairs reported a mean reduction of musculoskeletal complaints of −0.75 on a 7-point Likert scale in the first post-test. In contrast, those six subjects who did not adjust their chairs reported a mean increase in these complaints with 0.21 on the same scale. Furthermore, a significant correlation was found between the difference of gaze inclination and the difference of eye strain ($r = -0.43$, $p = 0.026$). Subjects who lowered their gaze reported less visual complaints.

4. Discussion

This field study was a proof of concept to examine whether employees can adjust their computer workplaces themselves only by using online information without personal expert contact. 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 (T0). Next, the intervention tool in the form of a website was introduced followed by employees' self-adjustments of the workplaces, using the web-based information. After the employees worked for 1 week (first post-test, T1) and 4 more weeks (second post-test, T2) with these settings, workplace data and self-reported complaints were collected again. As a result, it was found that subjects changed their computer workplaces individually in the intervention. These changes are supposed to be improvements as the subjects kept them rather unchanged up to 5 weeks and reported less musculoskeletal and headache symptoms after the intervention.

For testing the hypothesised individual effects in partly different directions, the classical analyses of variance for testing group mean effects were complemented by three different kinds of additional statistical analyses. The first, the geometrical analysis of shifts in monitor position relative to the eyes, is certainly most illustrative and follows the concept of individually different, but temporally stable preferred monitor positions (Jaschinski, Heuer, and Kylian 1998). The second and third methods are more formal statistical approaches: the individual changes between repeated measurements are tested with respect to the within-group variance of changes and correlations between days of testing. Both methods came to the same conclusion that individual changes in monitor inclination, head inclination and gaze inclination were significant. The correlation analysis has the advantage to emphasise and confirm the stability of the workplace conditions across the two post-intervention observations. However, correlations between pre- and post-intervention data were significantly smaller which indicates that pre-intervention settings differed from post-intervention settings.

The results indicate that all subjects except one used the website for modifying their computer workplaces. After they got access to the website, subjects worked with it by searching and reading about information concerned and altered their office furniture afterwards. They adjusted either the monitor, or the chair or both and changed in this way the general body posture in front of the computer. Although subjects' theoretical knowledge about the provided ergonomics information was not assessed by written or oral questions, it can be assumed that subjects enhanced their knowledge on office ergonomics as they put the theoretical information into practice. In future studies, it would be important to ask about the gained knowledge so that a more specific assessment of the impact of a web-based intervention is possible (Robson et al. 2012). However, the present study showed that for this group, a personal expert training was not necessary for the realisation of an office ergonomics intervention. They adjusted their computer workplaces without personal contact to experts. A possible explanation for this finding could be that similar to e-learning, subjects got a sense of control. They learned to think consciously about their workplaces and to modify actively the conditions for their individual requirements. Further research may assess the perceived sense of control, the perceived usefulness and the behavioural intention of the users as it has been shown that especially the last two aspects can have an impact on the effectiveness of electronic learning devices (Liaw 2008).

Ergonomics experience often reveals that employees do not accept the expert's suggestion for ergonomics changes. They tend to go back to their habitual workplace settings as they are not consciously aware of their workplace situation and possibilities. In the present study, subjects did not only adjust their workplaces in the intervention phase, but also retained these changes as their preferred position in the 5 weeks after having used the website. However, it is not suggested that this corresponding posture of body, head and eyes should be maintained statically over longer periods. Any static posture – even if physiologically reasonable – should be interrupted by dynamic changes to prevent the accumulation of prolonged low-level muscular contraction and the resulting complaints (Masuda et al. 1999). The human body needs flexibility and motion by nature and is not intended for static postures over longer periods. However, variability should not lead to sustained conditions that are ergonomically unfavourable. Therefore, physiologically favourable postures and ergonomic conditions are important to be used as starting positions or average postures around which variability is useful. Thus, from time to time, employees should change their posture, e.g. by adopting a standing working posture or moving around. This can be integrated into the working process when other tasks aside computer work has to be done or by using sit–stand workstations (Robertson, Ciriello, and Garabet 2013). The muscular activity in passive and active ways of sitting and standing are described by Grooten et al. (2013).

The measurement data of the pre-test indicated that subjects' workplace settings differed from each other, e.g. some had a backwards inclined monitor whereas others had partly a more forward inclined position of the monitor. As a consequence, individually different changes instead of main effects of the whole group were primarily found, meaning that adjustments in different directions were made. The vector analysis showed that the monitor positions relative to the eyes were changed in different ways: some subjects had closer positions whereas others had more distant positions after the intervention. This effect could occur as subjects differ physiologically in their body proportions, e.g. those with longer legs positioned the chair higher than those with shorter legs. Furthermore, subjects differ individually in their binocular coordination and resting vergence position of the eyes (Heuer et al. 1989; Jaschinski-Kruza 1991; Jaschinski 2002). Subjects with weak binocular coordination at near (i.e. an exo fixation disparity) prefer longer viewing distances than subjects with less fixation disparity (Jaschinski 2002; Jaschinski and Heuer 2004). These differences in biological causes with reference to body proportions and viewing aspects indicate the importance of individual adjustments and the consequences for people working at computers.

After subjects adjusted their workplaces and changed their body posture accordingly, fewer complaints were reported. The results indicate reductions of headache symptoms and musculoskeletal complaints after having used the website. Furthermore, no main effect of eye strain was found, although subjects reported less eye strain after the intervention. However, it is remarkable that musculoskeletal complaints were higher than eye strain and headache symptoms. This finding emphasises that especially the musculoskeletal system is affected during computer work. Taking a non-ergonomic posture for a longer period of time can lead to musculoskeletal problems. As the results of the present study showed, the right chair adjustment can have a significant impact on it. Contrary to those who did not modify their chairs, subjects who changed the chair adjustments reported less musculoskeletal complaints after the intervention than before. This result corresponds to earlier findings that an ergonomics sitting posture can lead to fewer musculoskeletal complaints (Robertson et al. 2009) as the spine gets relieved and less forced posture result in relaxed muscles.

However, not only the chair but also the right monitor position can affect bodily complaints. Analyses of the changes of the monitor position relative to the eye showed that after having adjusted the monitor and the chair, subjects had a more declined gaze, resulting in a more perpendicular gaze on the screen. 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. This is consistent with earlier findings that gaze inclinations within a range of $-5°$ to $-20°$ downwards induce less eye strain (Jaschinski, Heuer, and Kylian 1999; Lie and Fostervold 1995) and result in minimum perceived exertion of the eyes (Menozzi et al. 1994).

As in any occupational intervention study, the question arises whether the observed pre–post effects can be causally attributed to the fact that the participants used – as hypothesised – the ergonomic website for an improvement of their workplaces. Such a true experimental effect would be – in a theoretical way of thinking – the difference between what did happen due to the treatment, i.e. using the website in the present case, or would have happened if the same people simultaneously had not received the treatment (Shadish, Cook, and Campbell 2002). This thought experiment can only be approximated in real studies. Related to the non-treatment condition, it is useful to refer to a previous similar office intervention study where participants were tested over 4 weeks before the intervention took place (Jaschinski, Heuer, and Kylian 1999): during these control periods, the mean level of complaints did not change and the monitor position remained individually highly stable, although in those open-plane offices the employees used each day another workplace that they were able to adjust to their individual preferences. These observations suggest that employees tend to keep their individual workplace conditions and do not report lower complaints, if they are tested repeatedly in a non-intervention condition. It can be expected that this behaviour may also apply to the sample in the present study, where such a control condition could not be realised. Furthermore, two observations in the present study suggest that changes in self-reported complaints are not unspecific, but tend to be related to some particular changes at the workplace due to the website: the reduction in musculoskeletal strain was more pronounced in the subgroup that had adjusted the chair, and visual complaints were reduced in those participants who lowered their gaze, which is physiologically plausible (Jaschinski, Heuer, and Kylian 1998; Lie and Fostervold 1995).

Unspecific effects of pure participation in an intervention study are often referred to as 'Hawthorne effect'. Wickström and Bendix (2000) critically reviewed the original studies conducted in the Hawthorne Works of Western Electric (USA) initiated in 1924 and concluded that 'the available literature does not support the hypothesis that this same phenomenon – i.e. the Hawthorne effect – necessarily happens in other context.' Instead, Wickström and Bendix (2000) suggest that specific confounders should be considered that may have affected an intervention outcome. In the present study, factors such as daily hours of computer work, psychosocial stress and socio-economic characteristics could have had an impact on the findings. Thus, in future studies, at least these confounders should be analysed and a control group or repeated pre-intervention tests should be applied.

5. Conclusion

For this study a website was established, making use of the advantages of effective e-learning. The study indicates that employees – provided with flexible office equipment – can adjust their computer workplaces individually after having used the website: they adjusted their furniture, changed their body posture in front of the computer and retained that as their preferred position over 5 weeks. It is essential that employees are conscious of the flexibility of their workplaces and that already-made small adjustments can result in reduced complaints. Thus, the results of this proof of concept suggest that a website appears to be a promising cost-effective and simple alternative to the partly expensive and time-consuming expert training conducted so far in offices. The IfADo Ergonomic Vision website may be used as a tool in further ergonomics research and application to validate and extend the present findings.

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