

Motivating Ergonomic Computer Workstation Setup: Sometimes Training Is Not Enough

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Musculoskeletal disorders lead to pain and suffering and result in high costs to industry. There is evidence to suggest that whereas conventional ergonomics training programs result in knowledge gains, they may not necessarily translate to changes in behavior. There were 11 participants in an ergonomics training program, and a subsample of participants received a motivational intervention in the form of incentives for correct workstation setup. Training did not yield any changes in ergonomics measures for any participant. Incentives resulted in marked and durable changes in targeted workstation measures. The data suggest that improving worker knowledge about ergonomically correct workstation setup does not necessarily lead to correct workstation setup, and that motivational interventions may be needed to achieve lasting behavior change.

computer workstations incentives injury prevention musculoskeletal disorders training

1. INTRODUCTION

Research has established a link between musculoskeletal disorders (MSDs), and repetitive motion and/or improper posture at computer workstations [1, 2]. For example, workers who use computer keyboards in their work are more likely to develop occupational cumulative trauma disorders of the wrist than workers in other industries who engage

in repetitive manual tasks for extended periods during their workday [2]. A 2004 review cited five cross-sectional and one prospective study that concluded that hand and arm MSD outcomes were related to time spent at computer workstations [1]. Relationships between MSD outcomes for neck and shoulder and time at a computer were less consistent. In another study, bodily pain was directly associated with the time seated continu-

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ously at a computer workstation [3]. Pain was reported in 23% of people surveyed who sat over 120 min continuously at computer workstations, compared with 22% who spent 30–120 min, and only 11% who spent under 30 min daily sitting continuously at computer workstations. Bodily pain was defined very broadly, from moderate to unbearable, “either once per month or for longer than a week over the past year” (p. 622) [3]. The most common causes for pain cited by participants in this survey study included incorrect workstation setup, and working without breaks. Taken together, these studies suggest that interventions designed to improve posture could lead to prevention of MSDs.

Safety training is a common method of MSD prevention, and improvements in ergonomics knowledge have been observed after training. Nevertheless, the extent to which knowledge translates into better workstation setup or improved safety performance is unclear. It is possible that training programs can improve knowledge of ergonomics but have no impact on human factors measures [4] such as workstation setup or MSD symptoms. For example, one study found that despite the implementation of posture training and workstation manipulations to improve workstation setup and self-reported MSD symptoms of office workers, no differences were observed across two intervention groups and one control group in self-reported MSD symptoms [5]. The researchers also reported problems in consistently maintaining correct ergonomic setup of workstations [5].

These limitations of training may be associated with several disincentives that hinder ergonomic improvements to workstations. For instance, office workers who have worked in a certain position at the same workstation setup over extended periods of time may be reluctant to modify their postures or workstations. A new setup may feel “awkward” [6] or perhaps even impact work quality or output. One study found that people typed fewer words per minute after changing their typing posture [7]. Financial constraints may also hinder major ergonomic changes to workstations [8], as organizations may not be able to purchase fully adjustable equipment and office furniture. If

such disincentives exist in the work environment, an ergonomics training intervention alone may not be sufficient to motivate proper workstation setup and worker posture. Instead, a motivational intervention, such as goal setting [9], feedback [9], or even motivational interviewing [10], may be needed to supplement ergonomics training programs to achieve lasting changes in workstation setup and posture.

Evaluations of motivational interventions [11] such as goal setting, feedback, and incentives have been reported across a wide variety of safety-related behaviors in industrial and manufacturing settings [12], but the combination of motivational interventions and ergonomics training programs to establish and maintain ergonomically correct computer workstation setup has not been studied previously. The purpose of the current study was to evaluate the effects of ergonomics training followed by a motivational intervention in the form of a monetary incentive for maintaining keyboard tilt at ergonomic standards. We used a monetary incentive as a sample motivational intervention for reasons of convenience, but our results should generalize to other motivational interventions. We hypothesized that training alone would not lead to improvements in keyboard tilt, but financial incentives provided contingent on a correct setup would lead to higher levels of adherence. Finally, we hypothesized that removal of financial incentives would lead to decrements in correct keyboard tilt.

2. METHOD

2.1. Participants and Setting

Eleven participants were selected for participation in this study. They were members of a typing skills training classroom within the therapeutic workplace at Johns Hopkins Bayview Medical Center’s Center for Learning and Health in Baltimore, MD, USA [13]. Participants within this workplace spent ~4 h per weekday, divided into 2-h shifts (before and after noon), working at computer workstations while learning typing skills from a computerized typing training program. Participants ranged in age from 43

to 67 years; 8 were male and 3 were female. All participants were unemployed and lived in poverty, but were able to earn up to ~10 USD per hour for up to 20 h per week while attending the training program. The therapeutic workplace was divided into three classrooms; all participants in the current study worked in the same classroom. All participant computer workstations were outfitted with a keyboard tray with an adjusting tilt mechanism. This research was approved by the Western Institutional Review Board.

2.2. Dependent Variable

The dependent variable in this study was the tilt of keyboard tray. Trained research assistants measured two workstation features daily: tray front height and tray back height. Keyboard tray back height was defined as the vertical distance between the floor and the horizontal edge of the keyboard tray that was closest to the participant. Keyboard tray front height was defined as the vertical distance between the floor and the horizontal edge of the keyboard tray that was farther away from the participant. Keyboard tilt was calculated by subtracting keyboard front height from keyboard back height, so that a negative value indicated negative keyboard tilt. The Occupational Safety and Health Administration (OSHA) recommends a negative tilt of the keyboard, as it sets the occasion for a neutral position of the wrists, and upward bending of the wrist may lead to contact stress [14]. A yardstick was used to conduct measurements, and trained research assistants recorded measurements of the order of one third of a centimeter on an observational data sheet. Research assistants collected interobserver agreement data for 17.64% of all days of data collection, and scored a disagreement if two independent measures differed by over 1.25 cm. The interobserver agreement for workstation variables was 87% for keyboard tray front and 91% for keyboard tray back. A dependent variable score was not calculated for participants on days when they were absent during the entire day.

2.3. Independent Variable

This study included four successive experimental phases. Each phase corresponded to a level of the independent variable.

2.3.1. Phase 1: information

The information phase included providing participants with a one-page pamphlet, based on information from OSHA ergonomics guidelines for computer workstations [15] and the Cornell Human Factors and Ergonomics Research Group [16]. The content of the pamphlet included a basic definition of ergonomics, information about the proper workstation setup for the desk, keyboard tray, computer screen, keyboard, chair, and information about taking breaks, posture, and body movement. Participants could ask a research assistant any questions about the information in the pamphlet. They could also request a monitor riser to use at their computer workstations.

2.3.2. Phase 2: training

The training intervention consisted of a one-time ~30-min one-on-one interactive training session at a computer workstation. A research assistant followed a standard training script, which was based on ergonomics guidelines provided by OSHA [14] and the Cornell Human Factors and Ergonomics Research Group [16]. Participants received 1 USD per 10 min of participation in training (in addition to an hourly base salary of 8 USD). The training intervention consisted of providing information about ergonomic best practices, computer workstation setup training, and posture training. The workstation setup component of the training program included information on an ergonomically correct setup of

- desk and keyboard tray;
- keyboard and mouse;
- chair;
- armrests;
- computer monitor.

Throughout the stage of workstation setup, the research assistant asked participants about their current workstation setup (current comfort level,

knowledge of how to adjust workstation features, etc.). The research assistant collaborated with each participant on adjusting the workstation so that it was comfortable for the participant (based on the participant's report) and met OSHA ergonomics standards at the same time. The posture component of the training program included information about appropriate posture of

- head and eyes;
- neck;
- shoulders, arms and elbows;
- hands, wrists, and fingers;
- hips, legs, and knees;
- feet.

The research assistant asked participants to demonstrate their current posture at their desks, and then provided verbal instructions and prompts to assist participants in adopting correct postures. Participants communicated information about what felt most comfortable to them, and the research assistant gave them the opportunity to ask additional questions about posture. In addition, the training program also included information about the recommended frequency and duration of breaks from the computer workstation, as well as a pamphlet with a series of recommended exercises for computer workstation operators.

2.3.3. Phase 3: incentives

Five participants received a financial incentive contingent on maintaining a negative tilt of their keyboard tray. Participants received 2.50 USD for each 2-h work shift in which they were present at the workplace, and their keyboard tray was negatively tilted. The financial incentives earned at the workplace were in the form of vouchers exchangeable for goods and services, and the incentives earned from keyboard tray positioning were added to the participants' accounts at the end of each workweek. Because participants at the Center for Learning and Health could work 4 h a day, 5 days a week, the maximum weekly incentive was 25 USD.

The incentive was added to the participants' salary accounts on a weekly basis. The duration of the incentive phase varied by partici-

pant, and participants were notified prior to the termination of the incentive phase. The research assistant informed participants about the incentive contingency on the day prior to incentive commencement.

2.3.4. Phase 4: removal of incentives

Incentives were discontinued for 3 participants who had received incentives, and measurements of keyboard tilt continued. The purpose of this phase was to assess maintenance of behavior change over time in the absence of incentives.

3. RESULTS

Table 1 lists descriptive statistics for keyboard tilt for all participants across all phases of the study. To address the dependency resulting from having multiple measures for each individual, a two-level random effects regression model was run with tilt as the outcome variable and each of the phases dummy coded (with phase 1 as the referent category):

$$\begin{aligned} \text{tilt}_{it} &= \beta_{0i} + \beta_{1i} \text{ phase 2} + \beta_{2i} \text{ phase 3} \\ &\quad + \beta_{3i} \text{ phase 4} + r_{it} \\ \beta_{0i} &= \gamma_{00} + u_{0i} \\ \beta_{1i} &= \gamma_{10} \\ \beta_{2i} &= \gamma_{20} \\ \beta_{3i} &= \gamma_{30}, \end{aligned}$$

where r_{it} —residual between predicted tilt and observed tilt for person i at time t ; β_{0i} —estimated tilt for person i at phase 1, β_{1i} —estimated tilt for person i at phase 2, β_{2i} —estimated tilt for person i at phase 3, β_{3i} —estimated tilt for person i at phase 4, γ_{00} —average tilt across persons at phase 1, u_{0i} —residual for person i from average tilt at phase 1, γ_{10} —difference between average tilt at phase 1 and phase 2, γ_{20} —difference between average tilt at phase 1 and phase 3, γ_{30} —difference between average tilt at phase 1 and phase 3. In this fixed effects model, there is an assumption that the phase effects do not differ across persons and, therefore, $\beta_{1i} = \gamma_{10}$, $\beta_{2i} = \gamma_{20}$, and $\beta_{3i} = \gamma_{30}$.

TABLE 1. Summary Statistics for Keyboard Tray Tilt in Centimeters for Individual Participants by Phase

Participant	Phase							
	Information		Training		Incentives		Follow-Up	
	M	SD	M	SD	M	SD	M	SD
1	0.31	0.30	0.61	0.60	—	—	—	—
2	2.14	0.14	2.85	0.84	—	—	—	—
3	0.88	0.25	0.51	0.32	—	—	—	—
4	0.52	0.22	0.61	0.16	—	—	—	—
5	1.85	0.23	1.90	0.37	—	—	—	—
6	1.33	0.22	1.19	0.31	—	—	—	—
7	1.18	0.48	0.97	0.31	-0.81	0.28	-0.55	0.23
8	2.64	0.16	2.51	0.89	-0.75	0.38	-0.44	1.19
9	1.11	0.34	0.96	0.09	-1.22	0.97	-1.26	0.51
10	1.29	0.28	1.44	0.53	-0.86	0.30	—	—
11	3.18	0.44	2.57	0.51	-1.79	0.50	—	—

Given that measurements taken at proximal times are assumed to be correlated, an autoregressive (lag-1) error structure was imposed. Analyses were run using PROC MIXED within SAS version 9.1. Table 2 presents regression coefficients, SE, and associated *t* test values. Both phase 3 and phase 4 tilt measurements were significantly different from the measure at phase 1 (on average, 3.2 cm) and, as hypothesized, the tilt was in the negative direction. Fifty-eight percent of the variance in tilt can be accounted for by the phase of the study. Using phase 4 as the referent category in a subsequent analysis, phase 3 and phase 4 were not found to be significantly different from each other; $t(632) = -1.08, p = .280$.

TABLE 2. Summary of 2-Level Random Effects Regression Model

	Estimate	SE	<i>t</i>	df	<i>p</i>
Intercept (γ_{00})	1.487	0.144	10.29	10	<.001
Intercept (γ_{10})	-0.052	0.136	-0.38	632	.703
Intercept (γ_{20})	-2.651	0.206	-12.87	632	<.001
Intercept (γ_{30})	-2.383	0.286	-8.34	632	<.001

Notes. γ_{00} —average tilt across persons at phase 1, γ_{10} —difference between the average tilt at phase 1 and phase 2, γ_{20} —difference between the average tilt at phase 1 and phase 3, γ_{30} —difference between the average tilt at phase 1 and phase 3.

4. DISCUSSION

As hypothesized, the training intervention was unsuccessful in generating change in keyboard tray setup. No systematic changes in keyboard tray placement were identified across participants, as keyboard tray tilt slightly increased on average for some participants, and slightly decreased for others following ergonomics training. When participants were exposed to an ergonomically correct keyboard tray tilt during training, they appeared to prefer the nonergonomic positive tilt in the absence of incentives for a negative tilt.

Large and consistent improvements were only observed when incentives were implemented, as hypothesized. All 5 participants that were exposed to the incentive intervention adjusted their keyboard tray to have a negative tilt, and that change never occurred consistently before the incentives phase. Keyboard tilt was selected in the current study as the primary dependent variable for convenience purposes, but any workstation variable could in principle be targeted using the methods described herein.

Contrary to our hypothesized outcome, follow-up data indicate that improvements in workstation setup can be maintained after the discontinuation of incentives, as 2 out of 3 participants maintained proper keyboard tray tilt. Prolonged exposure to the ergonomically correct keyboard tray may have led to participants' becoming comfortable with the new setup; accordingly, a return to

a positive tilt would have been uncomfortable. Participant 8, e.g., slowly adjusted the keyboard tray to a more positive tilt during the follow-up phase. It is worth noting that the keyboard tray tilt for participant 8 during the information and training phases had a very pronounced positive tilt. Hence, a longer incentive phase, or alternative motivational interventions, may have been needed for participants who have previously set their keyboards at extreme levels of positive tilt before they become comfortable with a negatively tilted one.

Some variability exists within phases for individual participants, as evidenced by nonzero *SD* measures. This variability is most likely due to a combination of minor measurement error and minor changes in keyboard tray tilt over time. As the dependent variable was based on two measures, variability may have been introduced when measuring either keyboard tray front or keyboard tray back. Further, keyboard trays used in this study used a screwing mechanism to maintain keyboard tilt, and that mechanism became "loose" over time, which necessitated periodic re-adjustments of keyboard trays.

One potential limitation of this study is that we used a monetary incentive, which may be impractical and difficult to sustain over extended periods of time. However, this study can be considered a pilot study of the effects of a motivational intervention on ergonomic setup. In principle, any motivational intervention can be used to supplement ergonomics training programs as was done in the current study. Future larger-scale research should continue to address possible motivational interventions such as feedback, goal setting, and motivational interviewing, that can be used to further improve ergonomic setup, occasion good posture, and ultimately prevent MSDs.

Another potential limitation is that no formal reliability observations were conducted to verify the keyboard tilt during the workday. Participants could have adjusted their keyboard trays to have a neutral or positive tilt while working, and then modified it to have a negative tilt at the end of the workday during the incentive phase. Although the second author conducted informal covert assessments of keyboard tilt during work

hours for all participants, and routinely observed that participants were working with a negatively tilted keyboard, no reliability assessments were conducted on these observations. This potential weakness should be addressed more systematically in future research.

MSDs are prevalent in the workforce, costly to private industry, and may result in prolonged human discomfort or suffering. This study provides information on how behavioral interventions can be used to supplement ergonomics training. Training is necessary to educate workers about proper workstation setup and posture, but training may need to be supplemented with incentives to reliably generate lasting behavior change. The methods in the current study should translate easily to other workstation and postural variables, and monetary incentives may also be substituted with nonmonetary incentives such as public recognition, and/or time off.

REFERENCES

1. Gerr F, Marcus M, Monteilh C. Epidemiology of musculoskeletal disorders among computer users: lesson learned from the role of posture and keyboard use. *J Electromyogr Kinesiol.* 2004;14(1):25–31.
2. Matias AC, Salvendy G, Kuczek T. Predictive models of carpal tunnel syndrome causation among VDT operators. *Ergonomics.* 1998;41(2):213–26.
3. Polanyi MFD, Cole DC, Beaton DE, Chung J, Wells R, Abdolell M, et al. Upper-limb work-related musculoskeletal disorders among newspaper employees: cross-sectional survey results. *Am J Ind Med.* 1997;32(6):620–8.
4. King PM, Fisher JC, Garg A. Evaluation of the impact of employee ergonomics training in industry. *Appl Ergon.* 1997;28(4):249–56.
5. Gerr F, Marcus M, Monteilh C, Hannan L, Ortiz D, Kleibaum D. A randomised controlled trial of postural interventions for prevention of musculoskeletal symptoms among computer users. *Occup Environ Med.* 2005;62(7):478–87.
6. Agnew JL, Snyder G. Removing obstacles to safety: a behavior-based

- approach. Tucker, GA, USA: Performance Management; 2002.
7. Sigurdsson SO, Austin J. Using real-time visual feedback to improve posture at computer workstations. *J Appl Behav Anal.* 2008;41(3):365–75.
 8. Konarska M, Wolska A, Widerszal-Bazyl M, Bugajska J, Roman-Liu D, Aarås A. The effect of an ergonomic intervention on musculoskeletal, psychosocial, and visual strain of VDT data entry work: the Polish part of the international study. *International Journal of Occupational Safety and Ergonomics (JOSE).* 2005;11(1):65–76. Retrieved December 14, 2011, from: <http://www.ciop.pl/12383>
 9. Locke EA, Latham GP. Building a practically useful theory of goal setting and task motivation: a 35-year odyssey. *Am Psychol.* 2002;57:705–17.
 10. DiClemente CC, Velasquez, M. Motivational interviewing and the stages of change. In: Miller WR, Rollnick S, editors. *Motivational interviewing: preparing people for change.* 2nd ed. New York, NY, USA: Guilford; 2002. p. 217–50.
 11. Stajkovic A, Luthans F. Behavioral management and task performance in organizations: conceptual background, meta-analysis, and test of alternative models. *Pers Psychol.* 2003;56:155–94 (dx .doi.org/doi:10.1111/j.1744-6570.2003.tb00147.x).
 12. Wirth O, Sigurdsson SO. When workplace behavior depends on behavior change: topics for behavioral safety research. *J Safety Res.* 2008;39:589–98.
 13. Silverman K, Wong CJ, Needham M, Deimer KN, Knealing T, Crone-Todd D, et al. A randomized trial of employment-based reinforcement of cocaine abstinence in injection drug users. *J Appl Behav Anal.* 2008;40(3):387–410.
 14. Occupational Safety and Health Administration. Computer workstations. Checklist. Retrieved December 14, 2011, from: <http://www.osha.gov/SLTC/etools/computerworkstations/checklist.html>
 15. Occupational Safety and Health Administration. Computer workstations. Keyboards. Retrieved December 14, 2011, from: http://www.osha.gov/SLTC/etools/computerworkstations/components_keyboards.html
 16. Cornell University. Cornell University ergonomics web. Retrieved December 14, 2011, from: <http://ergo.human.cornell.edu>.

