THE MODERATING EFFECT OF THE SEVERITY OF BASELINE MUSCULOSKELETAL DISCOMFORT ON THE EFFECT OF AN ALTERNATIVE KEYBOARD: A 5-MONTH RANDOMIZED CLINICAL TRIAL

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Objective: To determine if baseline discomfort severity would moderate differences in 5-month follow-up discomfort in those using a fixed split-angle (FSA) keyboard compared to those using a standard (ST) keyboard. Procedure: Computer operators with keyboard related musculoskeletal discomfort were randomly assigned to use an FSA keyboard or a ST keyboard in their workplace for 5 months. They reported weekly levels of discomfort using the Weekly Discomfort Survey. Result: The interaction between baseline severity and keyboard was significant. This significant interaction suggests that those who had moderate/severe baseline discomfort who used the FSA keyboard improved significantly more than: 1) those who had moderate/severe baseline discomfort who used the ST keyboard; or 2) those who had none/mild baseline discomfort and used either keyboard.

Current theory postulates that sustained and awkward postures during computer keyboard use are one of the underlying causes of musculoskeletal discomfort (Rempel, 2008). One recommended method to reduce these postures is to use keyboards with alternative conformations (split, angled, tilted). Alternative keyboards have strong evidence supporting their ability to reduce postures that have been associated with discomfort (Baker & Cidboy, 2006), but very little conclusive evidence that they actually reduce discomfort in the workplace; most rigorous studies have found only minimal effects related to alternative keyboard use (Hedge et al., 2002; Moore & Swanson, 2003; Ripat, Giesbrecht, Quanbury, & Kelso, 2010; Ripat et al., 2006; Tittiranonda, Rempel, Armstrong, & Burastero, 1999).

Despite this limited evidence, alternative keyboards have proliferated during the last 20 years, such that they are the most frequently sold type of keyboard in the US (Rempel, 2008). Anecdotal evidence suggests that many computer operators find alternative keyboards to be effective. Thus, research is needed to understand for whom alternative keyboards are most effective.

A recent cross-over study found that there was no significant difference in discomfort in subjects who used a standard keyboard and an fixed split-angle keyboard over 5 months (Baker, Moehling, & Park, submitted). However, this same study did find that there was an effect of keyboard on medication use. A significant interaction effect between keyboard and group found that the difference in the proportion of subjects using medication was larger when they started with the fixed split-angle keyboard and switched to the standard keyboard (20% to 32% = 12%) than when they started with the standard keyboard and switched to the fixed split-angle keyboard (51% to 45% = 6%). These results indicate that the alternative keyboard was having some differential effect on study subjects. Since medication use is routinely associated with more severe symptomology, we completed a secondary analysis of the data to determine if the baseline discomfort severity would moderate differences in 5-month follow-up discomfort in those using a fixed split-angle compared to those using a standard keyboard.

METHOD

This is secondary data analysis of data from a parent study which used a randomized cross-over design (Baker et al., submitted). We have used data from only the first half of the trial, before subjects crossed over to the second half.

Subjects: Eligible subjects reported they used a work computer at least 20 hours/week and had a 2 or greater discomfort level on a Numerical Rating Scale (NRS) (0 = no discomfort, 10 = unbearable discomfort) in at least one of the following body parts: neck, back, right upper extremity (RUE) or left upper extremity (LUE). Exclusion criteria were a serious upper-extremity trauma injury, rheumatic disorders, or current use of an "ergonomic" keyboard.

Instrument: The outcome measure was the Weekly Discomfort Survey (WDS) (Gerr et al., 2005; Rempel et al., 2006), a self-report questionnaire assessing upper-extremity discomfort using a 11 point NRS scale (0 = no discomfort, 10 = unbearable discomfort). Subjects rated discomfort levels separately for neck/shoulder, back, RUE and LUE.

Intervention: The alternative keyboard was a fixed split-angle (FSA) keyboard (Microsoft Natural Ergonomics 4000 Version 1.0). The standard (ST) keyboard was a Lenovo Model No. Ku-0225 (Figure 1): a flat keyboard with a broad, thin wrist rest. Subjects were not told which keyboard was the control, and were encouraged to believe that both keyboards

A

B

Figure 1 – Study keyboards: A = fixed split-angle; B = standard

could reduce discomfort.

Procedure: In the parent study (Baker et al., submitted), subjects were randomly assigned the order in which they used the keyboards (ST/FSA or FSA/ST) over the two 5-month periods of the study. We have used data gathered over the first 5 months of the study (first period) and omitted data from the second 5 months. Thus, the study we are reporting is a randomized trial comparing subjects who used an FSA keyboard for 5-months to those using a ST keyboard for 5-months.

After baseline collection (demographic data, baseline WDS) subjects were randomized, and the appropriate keyboard was set-up in their workplace. Subjects used the keyboard for 5-months, completing a weekly WDS form online.

Data Analysis: We created a baseline discomfort severity score by dichotomizing the baseline WDS into none/mild discomfort (0 to 3) and moderate/severe discomfort (4 to 10) for each body part. We calculated a follow-up discomfort score by taking the mean score of the WDS data collected in the final 4 weeks of the study (month 5) for each body part (neck/shoulder, back, RUE, LUE).

We calculated means and frequencies for the demographic data.

Data at follow-up was highly skewed, as many subjects obtained a score of 0 (no pain - the lowest score). We were unable to use any transformation techniques to normalize the data. We, therefore, used the Wilcoxon Signed Rank Test to determine if there were significant differences between baseline and follow-up discomfort scores for subjects using each keyboard, and a Mann Whitney U to compare follow-up discomfort scores between groups (FSA vs. ST). We then evaluated the interaction effect of keyboard by severity by completing a logistic regression with the dichotomized follow-up score (discomfort/no discomfort) as the outcome variable and the interaction effect of keyboard by severity as the predictor variable. We plotted the interaction effect of these analyses using the mean scores to help with interpretation of the results. To further help with the interpretation we calculated an effect size Cohen's *d* for the difference in discomfort at follow-up between those with none/mild and moderate/severe baseline discomfort for each keyboard. Cohen's *d* is the difference between two means in standard deviation units. The effect size is interpreted as follows: Score <.20 indicates a negligible effect; score <.50 indicates a small effect; score <.80 indicates a moderate effect; and score ≥.80 indicates a large effect. Any score over 1 is considered to be a very large effect (Cohen, 1988)

As this was an exploratory study, alpha was set at $p = .10$

RESULTS

Seventy-four subjects completed data collection, 40 in the ST keyboard group and 34 in the FSA keyboard group. On average the subjects were 44.7 (SD 12.5) years old and 91.9% female. They used a computer on average 6.1 (SD 1.3) hours per day and 61.6% had taken a touch typing course. There were no significant differences between keyboard groups at baseline (p < .05)

There were significant improvements in discomfort from baseline to follow-up in both keyboard groups for all body parts (Table 1 – within *p*), but no significant differences in discomfort scores between keyboard groups at follow-up (Table 1 – between *p*).

The logistic regression found significant baseline severity by keyboard interaction effects for all body parts except the back (Table 2).

Table 1: Mean discomfort scores for baseline and follow-up within and between keyboard groups

	Discomfort		
Body part	ST (n = 40) M (SD)	FSA (n = 34) M (SD)	*between p*
<u>Neck/shoulder</u>			
Baseline	3.7 (2.3)	4.5 (2.4)	
Follow-up	0.7 (1.2)	0.6 (1.1)	.89
within p	<.001	<.001	
<u>Back</u>			
Baseline	3.3 (2.6)	4.0 (2.6)	
Follow-up	0.7 (1.4)	0.3 (0.8)	.33
within p	<.001	<.001	
<u>RUE</u>			
Baseline	3.4 (2.7)	3.5 (2.2)	
Follow-up	0.4 (0.7)	0.3 (0.6)	.86
within p	<.001	<.001	
<u>LUE</u>			
Baseline	2.1 (2.3)	2.1 (2.2)	
Follow-up	0.2 (0.6)	0.1 (0.2)	.88
within p	<.001	<.001	

M = Mean; ST = standard keyboard; FSA = fixed split-angle keyboard; RUE = right upper extremity; LUE = left upper extremity

Table 2: Results of logistic regression examining the association between the follow-up discomfort score at 5 months and baseline severity

		Follow-up Discomfort				
		N/M M (SD)	M/S M (SD)	St β	*p*	*d*
Neck/shoulder				-2.5	.002	
	ST	0.12 (0.4)	1.34 (1.5)			1.33
	FSA	0.41 (0.7)	0.75 (1.3)			0.33
Back				-0.8	.19	
	ST	0.14 (0.4)	1.49 (2.0)			1.14
	FSA	0.17 (0.5)	0.42 (1.0)			0.39
RUE				-1.3	.06	
	ST	0.07 (0.2)	0.72 (1.0)			1.10
	FSA	0.22 (0.6)	0.37 (0.6)			0.26
LUE				-2.1	.05	
	ST	0.04 (0.2)	0.54 (0.9)			0.90
	FSA	0.09 (0.3)	0.11 (0.2)			0.09

N/M = none/mild; M/S = moderate/severe; ST = standard keyboard; FSA = fixed split-angle keyboard; RUE = right upper extremity; LUE = left upper extremity; d = Cohen's d

We plotted the interaction of severity by keyboard using the mean follow-up scores. Figure 2 plots the neck interaction as an exemplar. It is typical of the plots for all the significant interaction effects. Those using the FSA keyboard had follow-up discomfort scores that were similar to each other regardless of whether they had none/mild or moderate/severe baseline scores. Those using the ST keyboard, however, had much higher follow-up scores for those who had moderate/severe baseline discomfort than those who had none/moderate baseline discomfort.

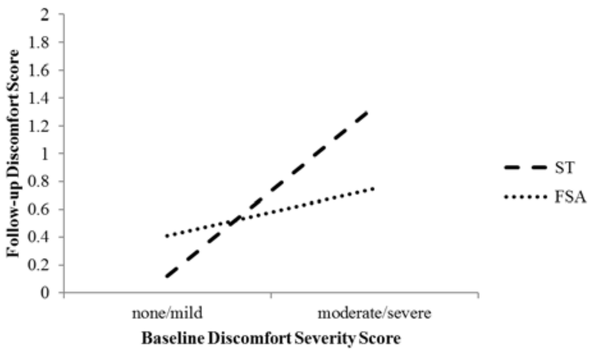

Figure 2 – Neck/shoulder interaction effect

DISCUSSION

This study examined the moderating effect of baseline discomfort severity on the effect of two types of keyboards (FSA and ST) on follow-up discomfort. When baseline discomfort score was not considered, computer operators' discomfort significantly improved over time regardless of keyboard type, generally reducing to almost normal levels. A between group comparison between all those using the FSA and all those using the ST keyboards indicated that there was no significant difference between groups at follow-up. However, when baseline severity was included in the model, there was a significant difference for neck, RUE and LUE follow-up discomfort between those with none/mild baseline discomfort and those with moderate/severe baseline discomfort depending upon which keyboard was used.

The results of this study suggest that those with more severe discomfort benefit more from the FSA keyboard than those with milder discomfort. Subjects with moderate/severe baseline discomfort who used the FSA keyboard were similar in their discomfort scores to those with none/mild baseline discomfort at the end of 5 months: Cohen's *d* indicates a small to negligible effect. However, those who had moderate/severe discomfort at baseline who used the ST keyboard had larger discomfort scores at the end of the study period than those who had none/mild discomfort at baseline: Cohen's *d* indicates a very large difference. Those using the FSA keyboard with moderate/severe baseline discomfort appear to have reduced their discomfort to levels similar to those with none/mild baseline discomfort, while those using the ST keyboard who had moderate/severe baseline discomfort had very large differences in their follow-up discomfort compared to those with none/mild baseline discomfort.

This analysis is supported by findings of the parent study (Baker et al., submitted). Medication use, which would be more likely to be used by those with more severe discomfort, decreased for a significantly greater proportion of those who used the FSA keyboard than for those who used the ST keyboard.

Other studies that have studied alternative keyboards have generally had results that only peripherally supported alternative keyboard use: often reporting only within subject improvements rather than between keyboard improvements (Hedge et al., 2002; Moore & Swanson, 2003). However, subjects in these studies generally did not have severe discomfort at baseline. The one study that did demonstrate significant improvements in discomfort for subjects using the alternative keyboard compared to a standard keyboard (Tittiranonda et al., 1999) was completed on subjects with carpal tunnel syndrome or tendinitis. The subjects in this study started with discomfort levels of 3, the score used to divide the subjects in the present study into none/mild or moderate/severe discomfort.

The study reported here supports providing an FSA keyboard to computer operators with moderate/severe discomfort, but not to those with none/mild discomfort. Our parent study (Baker et al., submitted) also found that people find it difficult to acclimate to the FSA board, another reason to refrain from providing the keyboard to those without moderate/severe discomfort. The time needed to adjust to the FSA keyboard coupled with its limited utility for those with none/mild discomfort suggest that it may be more trouble than it is worth. However, for computer operators with moderate/severe symptoms, the FSA keyboard may provide significant benefits that outweigh the difficulty of becoming acclimated to the new configuration.

One important question this study raises is whether FSA keyboards should be used as a method to prevent the development of discomfort or musculoskeletal disorders (MSD) in asymptomatic computer operators. This study hints that it should not. If FSA keyboards have limited effects on discomfort in computer operators who have mild discomfort, it seems unlikely that it will have an effect on the development of discomfort or MSD. Moore and Swanson (2003) assessed whether FSA keyboards could reduce the incidence of development of discomfort in asymptomatic computer operators. They reported a significant reduction in incidence for only one body part out of the nine measured. These two studies by no means definitively indicate that FSA keyboards cannot prevent MSD in asymptomatic computer operators, but they do suggest that research is needed to explore this important question.

Limitations: This study is a secondary data analysis on only half the data collection period of a cross-over design study. More rigorous primary research is needed to examine this question. The data in this study only examined baseline data and 5 month follow-up data. As discomfort can fluctuate tremendously over time, a study that looked at all data points between baseline and follow-up would provide a better understanding of the relationship between baseline severity and FSA keyboard use. Additionally, although those using the ST keyboard had greater discomfort than those using the FSA board, this discomfort was still fairly low (1.4 on an 11-point scale).

Conclusion: This study provides some initial support for using a FSA keyboard to reduce discomfort in computer operators with moderate/severe discomfort. Future research should focus on this as a primary research question and further explore the effect of other variables such as anthropometrics, BMI, and stress as modifiers of the effect of alternative keyboards on discomfort. In addition, the utility of a FSA keyboard in preventing the development of discomfort and MSD is needed. This will help to determine for whom and under what circumstances a FSA keyboard will benefit the most.

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