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The effect of forearm support on musculoskeletal discomfort during call centre work

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Abstract

Using a computer keyboard with the forearms unsupported has been proposed as a causal factor for neck/shoulder and arm/hand diagnoses. Recent laboratory and field studies have demonstrated that forearm support might be preferable to working in the traditional "floating" posture. The aim of this study was to determine whether providing forearm support when using a normal computer workstation would decrease musculoskeletal discomfort in intensive computer users in a call centre.

A randomised controlled study ($n = 59$), of 6 weeks duration was conducted. Thirty participants (Group 1) were allocated to forearm support using the desk surface with the remainder (Group 2) acting as a control group. At 6 weeks, the control group was also set up with forearm support. Both groups were then monitored for another 6 weeks. Questionnaires were used at 1, 6 and 12 weeks to obtain information about discomfort, workstation setup, working posture and comfort.

Nine participants (Group 1 $n = 6$, Group 2 $n = 3$) withdrew within a week of commencing forearm support either due to discomfort or difficulty in maintaining the posture. At 6 weeks, the group using forearm support generated significantly fewer reports of discomfort in the neck and back, although the difference between the groups was not statistically significant. At 12 weeks, there were fewer reports of neck, back and wrist discomfort when preintervention discomfort was compared with post intervention discomfort.

These findings indicate that for the majority of users, forearm support may be preferable to the "floating" posture implicit in current guidelines for computer workstation setup.

Keywords: Computer; Keyboard; Mouse; Posture

1. Introduction

The relationship between musculoskeletal disorders of the neck and upper extremity in association with computer use has been well documented (Pascarelli and Kella, 1993; Sauter et al., 1991). Risk factors associated with computer use include physical ergonomic factors such as keyboard, chair and monitor heights, working postures (Aaras et al., 1997; Grandjean et al., 1984), organisational factors such as duration of computer use per day and psychosocial factors such as stress (Smith and Carayon, 1996).

Discomfort of the proximal and distal upper extremities has been associated with the use of input devices such as the keyboard (Amell and Kumar, 2000) and mouse (Cook et al., 2000; Fogelman and Brogmus, 1995). Working without arm support has been proposed as one of the causal factors of neck and shoulder and arm hand diagnoses (Maeda, 1977; Erdelyi et al., 1988; Hagberg and Sundelin, 1986; Bergqvist et al., 1995). Despite this, the traditional "floating" posture in which a neutral wrist posture is maintained without supporting the arms is still widely used.

Upper extremity support has been reported to reduce static neck and shoulder muscle load during computer keyboard use (Aaras et al., 1998; Cook and Burgerss-Limerick, 2001; Marcus et al., 2002). Aaras et al. (2001) reported a significant decrease in neck, shoulder and back discomfort in a group of computer users who were

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able to support their whole forearm and hand on a concave workstation. No decrease in discomfort was reported for the distal upper extremity. In a recent prospective epidemiological study of computer users, Marcus et al. (2002) reported use of the keyboard placed more than 12 cm from the edge of the desk was associated with a lower risk of hand-arm symptoms. In a recent laboratory study, forearm support using a conventional desk was also found to result in significantly less ulnar deviation, less time spent in an extreme wrist posture and fewer reports of discomfort (Cook and Burgerss-Limerick, 2001).

Supporting the forearm on the work surface may decrease discomfort, decrease muscular load of the neck and shoulders and decrease harmful wrist postures, thereby creating a beneficial posture for keyboard and mouse users. However, the benefits of providing arm support during keyboard and mouse use in a conventional workstation have only been previously described in the laboratory setting (Cook and Burgerss-Limerick, 2001).

As the provision of specialised equipment such as concave desks is not always practical due to cost, the effect of adjusting a conventional workstation to allow forearm support during keyboard operation requires evaluation in a field setting.

1.1. Research aims

The aim of this study was to determine whether adjusting a conventional workstation to enable forearm support during computer use decreases reports of neck/shoulder or wrist/hand musculoskeletal discomfort in intensive computer users in a field setting.

2. Methods

Participants were experienced keyboard users who worked in a newspaper call centre. Eligible participants were employed for at least 15 h/week in the call centre and did not have more than one week of leave planned during the study. Anyone receiving treatment for musculoskeletal discomfort was excluded from the study. All eligible call centre employees were invited to participate ($n = 95$). There were 59 volunteers (54 female, 5 male). The average age was 39 years (range 21–68 years). The sample consisted of 21 full time, 36 part time and 2 casual employees. Average duration of computer usage was 29 h/week (SD 6.48 h). Mean duration of typing experience was 15 years (SD 11.9), with 79% reporting they had been taught to type, 8% were self-taught touch typists and 10% did not touch type.

Call centre staff are responsible for keying all information for classified advertisements. Information is taken either via the telephone or via email. The mouse is used frequently by those receiving advertisements via email, but rarely by those taking telephone calls. Management reported that about 75% of work time is spent keying. Pay incentives can be earned according to the number of calls answered, amount of text typed, and type of advertisement placed. The volume of calls processed within the call centre depends on newspaper advertisement deadlines. Computer workstations consist of adjustable-height desks, chairs and monitors and telephone headsets. Employees do not necessarily use the same workstation each day.

2.1. Design and measures

The study was a randomised controlled field trial of 6 weeks duration. As the study was conducted in an open plan office, the decision was made to provide intervention to the control group at 6 weeks. Both groups were then monitored for an additional 6 weeks. A random number table was used to randomise participants to two groups: the forearm support Group 1 (intervention at week 1, $n = 30$) and Group 2 (control group—intervention at week 6, $n = 29$).

2.1.1. Procedures

Week 1. Individual workstation assessments were conducted on each participant. Both groups received education about workstation set up and working posture. Their workstations were adjusted as outlined below:

(a) Group 1 (intervention): Workstations were adjusted to enable each participant ($n = 30$) to support their forearm (but not elbow) on the desk surface, maintaining neutral shoulder elevation. The keyboard was positioned so that the top row of keys was level with fingertips when the forearms were supported comfortably on the worksurface. The positions of the keyboard, desk and chair heights were recorded and marked with tape. The mouse was positioned next to the keyboard, so that at least half of the forearm was supported on the desk while working. Participants were monitored for the first few hours after the changes to their working posture to ensure that they were not adopting postures of trunk flexion, shoulder elevation or increased wrist extension. Participants were provided with a prompt sheet outlining how to maintain the forearm support position. Weekly visits were made to check compliance.

(b) Group 2 (control): Where required, adjustments to desk, chair and monitor height were made according to Australian Standards (Standards Australia, 1990).

2.1.2. Data collection

Week 1. A six-page self-report questionnaire was completed by each participant. The first section re-

quested information on the participant's work patterns, including hours of computer and computer mouse use at work and at home, break frequency and duration, and exercise (Cook et al., 2000). The second part of the questionnaire was based on the Nordic Questionnaire (Kuorinka et al., 1987). Participants were asked to record whether they had experienced musculoskeletal trouble (ache pain or discomfort) in the neck, shoulder, wrist/hand, forearm or back either in the past 12 months or within the last 7 days. Measurements of workstation dimensions were recorded before and after adjusting workstations. The keyboard and mouse position was recorded. Wrist rests, if used, were left in situ after workstation setup (26% of participants).

Week 6. Discomfort questionnaires were again completed by both groups and the forearm support posture (as described above) was introduced to Group 2.

Participants were monitored frequently after introducing the forearm support posture and weekly thereafter to ensure the consistency of working postures. Participants were requested to report any increases in discomfort.

Week 12. All participants completed the musculoskeletal symptom questionnaire and answered additional generated questions about the forearm support posture. A goniometer was used to measure shoulder flexion when the hands were positioned on the keyboard, with the fingertips touching the most distant row of keys (numeric or function keys) and the position of the keyboard remeasured.

2.2. Data analysis

Symptom prevalence was calculated preintervention, at 6 weeks and 12 weeks post intervention. Differences in proportions of symptoms between the control and intervention group at 6 weeks was analysed using χ^2. Differences in discomfort between preintervention and postintervention was analysed using McNemar χ^2 (Norman and Streiner, 1994). The results are of an intention to treat analysis, all those who withdrew from forearm support were included in the analysis.

3. Results

Within a week of intervention, nine participants (15%) withdrew from using forearm support either due to discomfort (4), or difficulty maintaining the posture (4). The forearm support posture was discontinued by the experimenter for one participant who was observed to adopt a posture of increased trunk flexion, due to her abdominal depth. The discomfort reported by these participants on discontinuation of the forearm support posture has been included in the analysis. Two other participants were eliminated from the study, due to unexpected absences. Of the 48 participants who continued, 23 completed 12 weeks and 25 participants completed 6 weeks with forearm support.

3.1. Musculoskeletal discomfort

3.1.1. Before intervention ($n = 57$)

All but one participant reported having had musculoskeletal discomfort in one or more body region in the past 12 months, with 75% reporting discomfort in the 7 days preceding study commencement. There were no differences in overall symptom reporting between the 2 groups prior to intervention ($\chi^2 = 0.478$, $p = 0.49$). One-third of the participants reported having received treatment for their discomfort within the past 12 months.

Week 6.

(a) Group 1—intervention: The proportion of participants reporting discomfort in one or more body area in the previous 7 days decreased from 79% in week 1 to 62% in week 6 ($\chi^2 = 0.468$, $p = 0.227$) (Fig. 1).

(b) Group 2—control: Reports of discomfort increased slightly for all body regions for this group of participants, with overall discomfort increasing from 71% in week 1 to 75% in week 6 (Fig. 1).

There were no significant differences between the intervention and control groups for any body regions (Table 1).

Week 12 ($n = 57$). There was a significant decrease in overall discomfort for the whole group (i.e. discomfort in any body region) between week 1 (75%) and 12 (45%) ($\chi^2 = 0.773$, $p = 0.002$). The proportion of participants reporting neck ($\chi^2 = 5.05$, $p = 0.008$), wrist ($\chi^2 = 0.93$, $p = 0.021$) and forearm ($\chi^2 = 0.062$, $p = 0.049$) discomfort decreased between weeks 1 and 12. Shoulder and back discomfort had also decreased although these changes were not statistically significant (shoulder

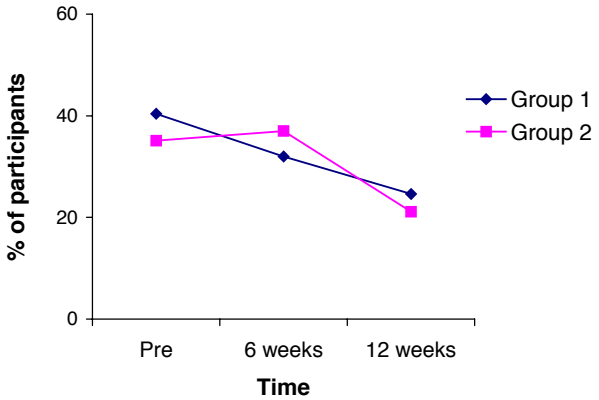

Fig. 1. Overall discomfort: the proportion of participants reporting discomfort in one or more body regions in the previous 7 days over the duration of the study.

Table 1
Percentages of discomfort reported by each group for each body area at each measurement occasion. Level of significance (p) indicated for differences between Group 1 (intervention) and Group 2 (control)

Region of discomfort	Pre		6 weeks			12 weeks		
	Gp 1	Gp 2	Gp 1	Gp 2	p	Gp 1	Gp 2	p
Neck	21	18	18	26	0.15	11	7	0.52
Shoulder	18	18	19	24	0.36	18	8	0.15
Forearm	11	14	9	18	0.11	5	4	0.66
Wrist	12	11	7	11	0.45	2	4	0.53
Back	12	14	14	26	0.08	11	11	0.95
Any	40	35	32	37	0.29	25	21	0.68

$\chi^2 = 2.9$, $p = 0.36$), (back $\chi^2 = 4.4$, $p = 0.61$). There were no significant differences in reporting of discomfort between the two groups (χ^2 0.139, $p = 0.68$).

3.2. Subjective reports

Of the group ($n = 48$) who continued with forearm support, two participants reported that they had used the forearm support posture minimally during the study. They reported that they had not found the position comfortable, and found that because they changed workstations between shifts it was too difficult to set up. Thirty-two percent of participants reported using forearm support some of the time, and 64% used forearm support all of the time. The main reason given for not always using the forearm support posture was speed and difficulty getting used to the new technique.

Of the total group (including those who discontinued forearm support), 11 participants (19%) reported that they found the forearm support position less comfortable, 16% reported the same level of comfort and 61% more comfortable than their previous working posture. Two participants did not respond to this question (4%). Reasons given for increased comfort included being able to rest the arms resulting in less pain (3), less strain (4), a more balanced posture (2) and more space (1). Three people reported adjustments other than forearm support such as their leg position as a result of altered chair height or monitor height as being reasons for their increased comfort. Difficulty adjusting to the new posture was reported by four people.

3.3. Mouse use

Mouse users fell into two groups with 61% of participants using their mouse most of the day, with the remainder using their mouse less than 1 h/day. There were no significant differences in discomfort for any body region before or after intervention between these two groups. Preintervention, 77% of mouse users reported experiencing discomfort in one or more body regions, decreasing to 51% at 12 weeks ($\chi^2 = 0.22$, $p = 0.096$, df 1). The prevalence of wrist symptoms in mouse users decreased from 20% preintervention to 6% postintervention ($\chi^2 = 0.18$, $p = 0.64$, df 1). Similarly, forearm symptoms decreased from 17% preintervention, to 6% postintervention ($\chi^2 = 0.29$, $p = 0.82$, df = 1).

3.4. Wrist rests

Fifteen participants (26%) used solid foam wrist rests prior to commencement of the study. On completion of the study, this had increased to 26 participants (46%). The researcher introduced the use of wrist rests to six participants during the initial set up into forearm support posture. These participants were observed to rest their wrists on the worksurface while keying resulting in wrist extension. The other five participants commenced using wrist rests due to reports of pressure on the forearm from the edge of the desk. The majority used the wrist rests adjacent to the keyboard, with six using the wrist rests under their forearm close to the edge of the desk.

3.5. Position of the keyboard

The mean angle of shoulder flexion when working in the forearm support posture was 21° (SD 9.3, range 5–50°), with four subjects positioned in more than 30° of shoulder flexion.

The mean distance of the keyboard from the desk edge increased significantly ($t = -9.05$, $p < 001$, df 47) from 95 mm (SD 50.46) prior to set up, to 168 mm (SD 50. 7) at 12 weeks. The computer mouse was positioned adjacent to the keyboard enabling forearm support during mouse use.

4. Discussion

There were no significant differences between the control and intervention groups at 6 weeks. However, reports of discomfort within the intervention group had decreased while those in the control group had increased. Once set up with forearm support, a reduction in reported discomfort occurred within 6 weeks for both groups. When comparisons were made between pre- and postintervention of forearm support, a significant decrease in the frequency of reported neck, back, forearm and wrist discomfort was found. Nearly two-thirds of participants reported using the forearm support posture all of the time, with about three-quarters reporting it more comfortable than their previous work posture. While 20% of participants reverted to a floating posture due to discomfort or

dislike of the forearm support position, the majority of users reported an improvement in comfort.

The findings of fewer reports of neck, shoulder and back discomfort are consistent with those of a previous study on forearm support, with some differences in symptom reporting noted between the two studies for the distal upper extremity (Aaras et al., 1998, 2001).

Significant reductions in reported wrist and forearm discomfort at 12 weeks contrasts with the lack of difference in discomfort intensity after initial intervention in a previous study (Aaras et al., 1998), with a tendency for increased forearm/hand pain over 6 years reported for two of the study groups (Aaras et al., 2001). In the current study, one-quarter of participants used wrist rests on study commencement, with a further quarter of the subjects provided with wrist supports during the study either due to observed wrist extension or reported discomfort from the desk edge. Although not measured, regular observation was conducted by the researcher to check that participants were not working in wrist extension. Due to the possible relationship between wrist rests and increases in carpal tunnel pressure (Horie et al., 1993), wrist supports were placed under the forearm rather than adjacent to the keyboard where possible (Hedge, 2001). Consistent with a previous laboratory study (Cook and Burgerss-Limerick, 2001) whilst working with forearm support, participants were observed to pivot their forearms rather than anchoring their wrists and working in ulnar deviation. Although Marcus et al. (2002) reported an association between use of wrist rests and hand-arm symptoms and disorders, this was for the group who used their keyboard less than 12 cm from the edge of the desk, a working position which they associated with increased risk. The current study confirms those of Marcus et al. (2002), wrist rest use and forearm support were not related to an increase in wrist discomfort.

Most participants in this study were working in less than 30° of shoulder flexion. Working in shoulder flexion of more than above 30° has been associated with increased shoulder discomfort or decreased performance in the unsupported arm (Sauter et al., 1991; Straker et al., 1997). However, the effect of this shoulder posture in the supported arm has not been reported. Marcus et al. (2002) reported an association between inner elbow angles of >121 degrees and a decreased risk of neck shoulder symptoms. Although not examined separately, this elbow posture was associated with a mean shoulder flexion of 38°.

There was a non-significant increase in discomfort reported at 6 weeks for Group 2 (prior to intervention). Both groups had received education regarding correct workstation setup at the commencement of the study. As most workstations were well adjusted, minimal changes were made to the workstations of the control group. The positive benefit of education alone has been questioned in some studies. An increase in discomfort was reported post intervention in a study where self education had been a major component (Coury, 1998). An increase in forearm/hand pain was reported following a traditional education programme (Bohr, 2000). Lewis et al. (2001) reported that education by professionals with subsequent workstation adjustment by employees did not result in a significant decrease in musculoskeletal discomfort.

The main limitation of this study is the short time of the test period. Although pre to post intervention decreases in discomfort were found following forearm support, a randomised controlled trial of longer than 6 weeks duration would potentially provide more conclusive results.

5. Conclusion

The results of this study confirms that use of forearm support has a number of advantages over a traditional floating posture and should be considered as an alternate working posture for keyboard users.

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