EFFECTS OF AN ELECTRIC HEIGHT-ADJUSTABLE WORKSURFACE ON SELF-ASSESSED MUSCULOSKELETAL DISCOMFORT AND PRODUCTIVITY IN COMPUTER WORKERS

Cornell University Human Factors and Ergonomics Research Laboratory
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ABSTRACT

This report describes results for a study of electric height-adjustable worksurfaces (EHAWs) conducted in two companies. A total of 33 computer workers from the two companies worked at fixed-height worksurfaces (FHWs) and then at EHAWs for between 4 and 6 weeks. Participants completed extensive survey questionnaires immediately before and then 4-6 weeks after using the EHAWs. Results showed significant decreases in the severity of musculoskeletal discomfort for most upper body regions. In the EHAW condition daily discomfort ratings were lower in the afternoon and productivity ratings improved. Written comments about the EHAWs generally were positive. There was a strong preference for using the EHAWs. Implications are discussed.

1. INTRODUCTION

Alternating between a sitting and standing posture at work appears to benefit health and productivity. Argiropoulos and Seidel-Fabian (2002)reviewed the potential benefits of using high desks for standing work and concluded that they can be a health-supporting measure for office workers and people working at display workstations. Paul and colleagues have demonstrated several benefits associated with sitting, standing and moving throughout the workday. Paul (1995a) measured foot swelling in 6 VDT operators who first worked with nonadjustable sitting workstations and then worked for six weeks with sit-stand adjustable furniture. In the sit-stand condition, operators stood for 15 minutes every hour. In both settings, the foot swelling was measured at 8 a.m., 12 p.m., 1 p.m. and 5 p.m. using a foot volume meter. Between 12 p.m. and 1 p.m., subjects walked for 20 minutes and sat for 40 minutes. The results showed that the average right foot swelling in offices with sit-stand adjustable furniture was significantly less than that in offices with nonadjustable furniture, 12.3 ml (1.1 percent) compared to 21 ml (1.8 percent). These results suggest that activity promoted using sit-stand workstations benefits sedentary office workers.

A controlled field study by Paul and Helander (1995a) measured spinal shrinkage in 13 office employees, of whom ten were healthy and three had spinal disorders. Employees worked at sit-stand type workstations. Stature was measured at 8 a.m., 12 p.m., 1 p.m. and 5 p.m. using a stadiometer. All subjects sat for 40 minutes and walked for 20 minutes between 12 p.m. to 1 p.m. Six of the ten healthy employees were instructed to stand for 30 minutes four times during the day and four subjects stood eight times 15 minutes each. There was significantly less spinal shrinkage for office workers who stood in 30 minute sessions compared to those who stood in 15 minute sessions. Office workers with spinal disorders also stood eight times 15 minutes each and showed a greater variability in the shrinkage pattern. In another similar study, Paul and Helander (1995b) measured spinal shrinkage in 18 office employees with VDT-intensive sedentary (n=14) and non-sedentary (n=4) VDT jobs. Eleven of the 14 sedentary operators were healthy and three were unhealthy with spinal disorders. The non-sedentary operators walked for an average 4.25 hours during the eight hour workday. Stature was measured, using a stadiometer, at 8 am, 12 pm, 1 pm and 5 pm, and from 12 pm to 1 pm, all subjects sat for 40 minutes and walked for 20 minutes. The office workers with sedentary jobs showed significant spinal shrinkage that occurred continuously throughout the day. In unhealthy subjects, the shrinkage process stabilized within the first four hours of work. The office employees with non-sedentary jobs showed significantly less spinal shrinkage than those with sedentary jobs.

Beynon and Reilly (2001) studied 10 female subjects who completed 4 hours of simulated nursing activities on two separate trials. The two trials were identical except that subjects sat for a 20-min break in one and stood for a 20-min break in the other trial. Heart rate, discomfort, rating of perceived exertion and spinal shrinkage were recorded at various intervals throughout testing. Spinal shrinkage was significantly less during the seated trial than the standing trial ($p<0.05$). A seated break during the shift reduced the potential of suffering back problems resulting from spinal loading.

Dainoff (2002) conducted a laboratory study that investigated the effects of working at a sit-stand keyboard tray. During the test, subjects stood ~2.5 times per day for an average ~6 minutes per stand. Subjects who chose to intermittently stand took fewer and shorter breaks and showed better productivity. Nerhood and Thompson (1994) studied the introduction of sit-stand workstations in an office within United Parcel Service (UPS). All the employees were full-time computer users. All employees received ergonomics training that provided instruction in how to properly use the new workstations, chairs, and other accessories. Various benchmark data were collected on production levels, absenteeism, and injuries and illnesses were collected and a survey of body part discomfort was conducted prior to the installation of the sit-stand workstations. The same data were gathered after the installation of the workstations. Results showed that workers averaged 3.6 adjustments to standing position per day and spent an average 23% of the time per day in a standing position. Body part discomfort decreased by an average of 62 percent and the occurrence of injuries and illnesses decreased by more than half.

Absenteeism did not show significant changes. Feedback from employees on sit-stand was very positive.

Paul (1995b) reported a study of 12 office employees doing computer-intensive jobs. Initially, they worked in enclosed offices and sat at non-adjustable workstations. Then they worked in more open offices with three walls and sit-stand adjustable VDT workstations. The effects of this office redesign were evaluated three months post-occupancy. During the three months, employees worked standing for two hours every day. The results suggest that change in the office layout, i.e. open versus closed, increased the interaction and communication between employees although, it significantly decreased employees' perceived privacy, and increased the amount of visual and noise distractions. In the offices with sit-stand adjustable furniture, subjects reported feeling more energetic and less tired by the end of the workday. Roelofs and Straker (2002) studied the discomfort and preferences of 30 full-time bank tellers, who worked at a standing height worksurface in each of three conditions: just sitting on a high chair, just standing, and alternating between a sitting and standing work postures. The just sitting posture resulted in the greatest upper limb discomfort ratings, and the just standing posture resulted in the greatest lower limb discomfort ratings. Alternating between sitting and standing resulted in least discomfort and was reported as the preferred posture by 70% of subjects.

The use of height-adjustable furniture may allow a worker to vary their posture, from sitting to standing throughout the workday, and to position their worksurface at a comfortable level regardless of the posture adopted. Height adjustable furniture designs initially required a user to manual crank a handle to position the height of the worksurface. However, early designs of manual cranks suffered several limitations – crank handles were poorly located, they required effort to operate, especially when the surface was loaded with the weight of equipment, and they took considerable time to adjust. In the 1990s, electric height-adjustment systems emerged that allowed for faster, easier changes in surface height, but these products were costly. Recent advances in the design of adjustment mechanisms have substantially reduced these costs, making electric height-adjustable (EHA) worksurfaces a viable design option for offices. There is good evidence to indicate that adjustable furniture that can support sit-stand working may be beneficial to the health and performance of office workers. The present study was conducted to test the effects of using electric height-adjustable (EHA) worksurfaces in offices.

2. METHODS

2.1 Survey Sample

Participants were recruited at two facilities, one was a high technology facility on the west coast and the other was an insurance company in the mid-west. Between these two facilities a group of 53 employees volunteered to participate in the study. Thirty-five participants were recruited from the high-technology company and 18 from the insurance company. All participants were full-time employees and intensive computer users. Initially, all participants worked at a fixed height worksurface (FHW), 45 of the participants subsequently experienced working at an electric height adjustable worksurface (EHAW). There was some uncontrolled attrition and some respondents failed to complete both the pre-test and post-test survey questionnaires. At the end of the study complete and matched survey data were available for 33 participants.

2.2 Procedure

All participants completed a baseline survey questionnaire that asked them about their work patterns and about the musculoskeletal discomfort that they experienced at work. In the insurance company all participants completed a pre-test survey. Following this, one group of employees was randomly assigned as a control group that did not receive any changes to their FHWs, while the other became a test group that received the EHAWs. One month later, both groups were surveyed again with a modified questionnaire that asked the test group about their experiences with the EHAWs. In the high-technology company the same initial survey procedure was followed, but at the end of the first test period the control and test groups were switched in a cross-over design: the EHAWs were removed from the former test workstations and installed in the former control workstations, and they were replaced with the original FHWs. Approximately another four to six weeks later, both groups were surveyed again with the modified questionnaire that asked the new test group about their experiences with the EHAWs. In this way, all participants were able to experience working for at least one month at a FHW and at least a one month period working at an EHAW.

At the end of the study the matched results for the insurance company test group and the high technology groups were merged for analysis. The pre-test surveys were conducted in the fall of 2003; the EHAWs were first installed in both facilities in August/September 2003; in the high-technology facility the EHAWs were switched in November 2003; and the data collection phase of the study was concluded in January 2004.

Several issues were encountered with the study design: there were several changes in participation because of employment changes; the two groups of participants did not have an identical mix of right and left hand worksurfaces; participants were not trained in the use of the EHAWs, and initially some EHAWs didn't function properly which caused some work disruption and created some negative opinions. These teething problems apart, the study design also had to be slightly modified because in the high-technology facility three participants experienced such improvements in their symptoms they kept their EHAWs at the end of the first test phase, so these were not available for use in the cross-over design.

2.3 Data Analysis

All questionnaire survey data were computer coded. Data for each of the two facilities were merged into a file containing the survey responses for the one month at the FHWs immediately prior to working at the each EHAW, and the survey responses after the one-month working at the EHAWs. Pre-and post test survey data were matched for each participant, and this yielded a total of 33 matched surveys for sequential control month followed by test month surveys. Data were analyzed using a multivariate statistical package (SPSS V12). Survey responses to working at the FHW and EHAWs were compared using the Wilcoxon Signed-Ranks test or a paired t-test. A 5% significance level was chosen and all p values are two-tailed.

3.0 RESULTS

3.1 Work patterns

Participants answered a series of questions that asked about their daily work patterns. The FHW and EHAW comparison results are summarized below. There were no significant changes in the work patterns for the FHW vs EHAW conditions for daily use of a computer keyboard (57.6% vs 59.5%) or mouse (64.3% vs 62.2%). The work patterns for using a computer keyboard (Figure 1) or mouse (Figure 2) before-and-after the use of the EHAWs show that around 30% used a keyboard and 50% used a mouse for more than 75% of the day during both the control and test periods. Results show that on average participants reported spending about 60% of the day using a mouse and over 50% of the day using a keyboard during both the control and test periods (Table 1).

Figure 1 Daily keyboard use for the FHW and EHAW treatments

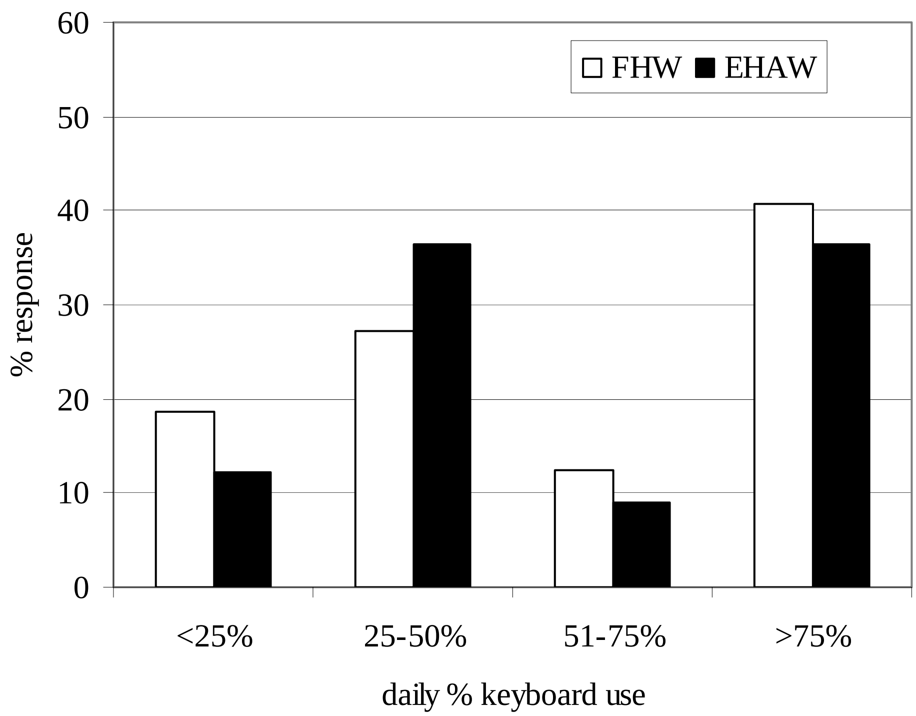


Figure 2 Daily mouse use for the FHW and EHAW treatments

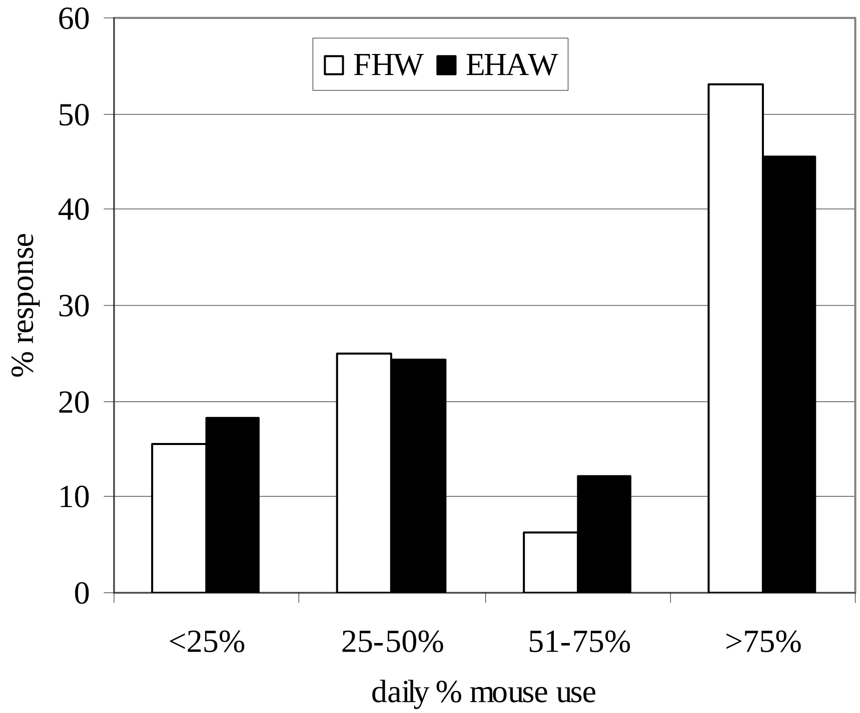


Table 1 Mean percentages of work patterns for the FHW and EHAW conditions

	FHW	EHAW	Z	DF	P
% day using a mouse?	64.3	62.2			ns
% day using a keyboard?	57.6	59.5			ns
% day discussing work with colleagues in your cubicle?	19.7	13.8	-1.92	*30*	*0.055*
% day discussing work with colleagues in their cubicles or in meeting room	16.4	14.2			ns
% day standing at worksurface to do your work?	8.3	21.2	-3.202	31	0.001
% day sitting at worksurface to do your work?	87.7	71.4	-4.023	31	0.000

There was a marginally significant decrease in the average percentage of time spent discussing work with colleagues in the participants own cubicle for the EHAW condition but no difference in the average percentage of time spent in discussions with colleagues in another cubicle or meeting room.

There was a significant increase in the daily time that subjects reported standing to do work with the EHAWs (8.3% vs 21.2%: Z(31)=-3.20, p=0.001), and a significant decrease in the percent of time sitting to do work (87.7% vs 71.4%: Z(31)=-4.02, p=0.000). The adjustments past the midpoint of the height range of the worksurface was counted for a subset of 17 Ss and an average of 28 such adjustments were made over the initial test period (approximately 1.5 adjustments per day). There was a significant correlation between the mean daily adjustments and the self-rated frequency of adjustment (r=0.47, p=0.028: 1 tailed).

There was no significant increase in ratings of the frequency of standing to do work at the work surface. The actual frequency distribution of responses is shown in Table 2, and the percentage responses plotted in Figure 3. Participants also reported an increase in the frequency of taking short breaks from computer work when they were using the EHAWs.

Figure 3 Percentages of participants and frequency of daily standing to work for the FHW and EHA

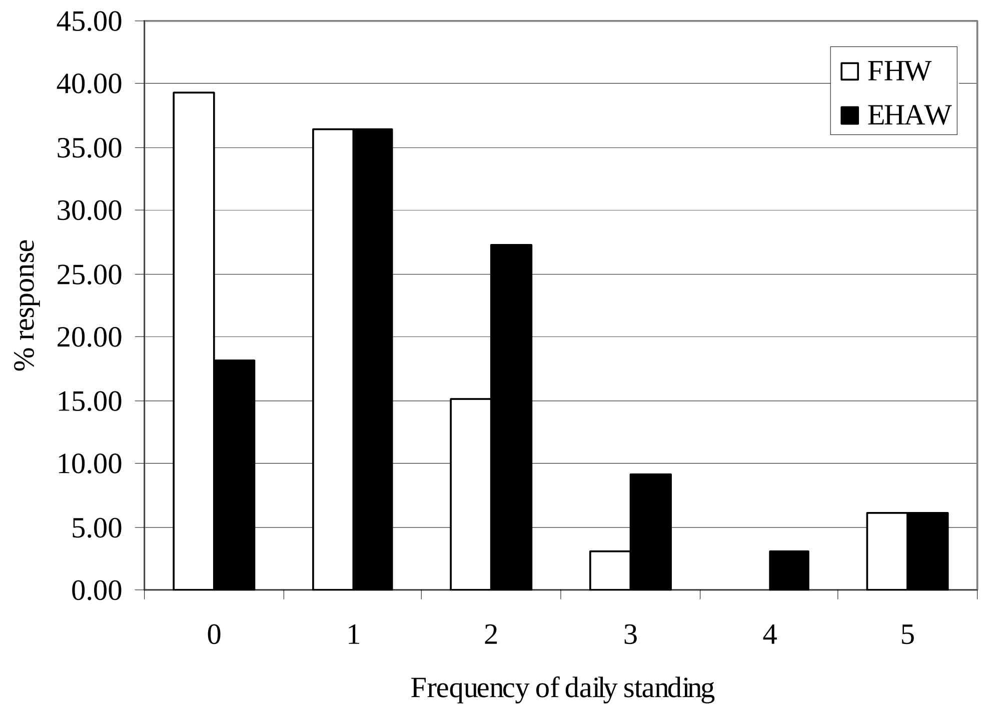


Table 2 Frequency of standing to work each day

	0	*1-2*	*3-4*	*5-6*	*7-8*	*>8*
FHW	13	12	5	1	0	2
EHAW	6	12	9	3	1	2

3.2 Severity of Musculoskeletal Discomfort

Participants answered a series of questions that asked about the severity of musculoskeletal discomfort experienced over the previous 4 weeks period for various body regions. The FHW and EHAW comparison results are summarized below in Table 3. There were significant decreases in the prevalence of MSD symptoms (none vs mild/moderate/severe symptoms) for the left eye, right neck, left and right upper back, left and right lower back, left thigh, left and right shoulders, right upper arm, right elbow, left and right forearms, left and right wrists and left and right hands. Figure 4 shows the percentages of MSD reports for each condition.

3.3 Frequency of Musculoskeletal Discomfort

Participants answered a series of questions that asked about the frequency of musculoskeletal discomfort (MSD) experienced over the previous 4 weeks period for various body regions. The FHW and EHAW comparison results are summarized below in Table 4 and in Figure 5. There was a slight but statistically significant decrease in the frequency of symptoms for the right and left eyes, left neck, right neck, left upper back, right upper back, left lower back, right lower back, left thigh, left shoulder, right shoulder, right upper arm, left elbow, right elbow, left forearm, right forearm, left wrist, right wrist, left hand and right hand. There was a marginally statistically significant decrease in the frequency of symptoms for the left foot. Other than these changes, no other differences were statistically significant.

3.4 Musculoskeletal Discomfort Index

An index of musculoskeletal discomfort was created by multiplying the frequency of discomfort score by the severity of discomfort score for each symptom for each participant, then summing the product for all body regions and finally averaging this score for all participants. The mean musculoskeletal discomfort index score was 43.1 for the FHW and 35.1 for the EHAW, which is almost a 20% decrease, and the difference was statistically significant ($t(31) = 2.319$, $p = 0.027$).

3.5 Changes in the Severity of Musculoskeletal Discomfort

Participants were asked to indicate the effect of the height adjustable work surface on how any work-related musculoskeletal discomfort symptoms had changed. Virtually none of the participants said that their symptoms were much worse with the EHAW. Very few participants indicated that the symptoms had worsened with the EHAW, and many participants indicated that their symptoms had improved (see Table 5 and Figure 6).

Table 3 Percentage prevalence of musculoskeletal discomfort symptoms rated as mild, moderate or severe for the FHW and EHAWs.

	FHW	*EHAW*	*Z*	*df*	*P*
left eye	54.5	30.3	-2.066	33	0.039
right eye	57.6	36.4	ns	33	ns
left neck	66.7	54.5	*-1.882*	*33*	*0.06*
right neck	69.7	60.6	-2.556	33	0.011
left upper back	63.6	57.6	-2.056	33	0.04
right upper back	69.7	54.5	-2.623	33	0.009
left lower back	72.7	57.6	-2.588	33	0.01
right lower back	75.8	57.6	-3.216	33	0.001
left hip	33.3	24.2	ns	33	ns
right hip	36.4	21.2	ns	33	ns
left thigh	27.3	9.1	-2.565	33	0.01
right thigh	18.2	9.1	ns	33	ns
left lower leg	21.2	15.2	ns	33	ns
right lower leg	21.2	18.2	ns	33	ns
left foot	30.3	21.2	*-1.897*	33	*0.058*
right foot	30.3	21.2	ns	33	ns
left shoulder	63.6	42.4	-2.964	33	0.007
right shoulder	60.6	54.5	-2.627	33	0.009
left upper arm	42.4	33.3	ns	33	ns
right upper arm	36.4	42.4	ns	33	ns
left elbow	33.3	27.3	ns	33	ns
right elbow	42.4	36.4	-2.153	33	0.031
left forearm	48.5	24.2	-2.84	33	0.005
right forearm	57.6	39.4	-2.501	33	0.012
left wrist	60.6	36.4	-3.116	33	0.002
right wrist	69.7	51.5	-3.343	33	0.001
left hand	57.6	33.3	-2.879	33	0.004
right hand	66.7	51.5	-2.362	33	0.018

Italicized items are marginally significant. All statistical analyses performed on full 4-point scale data. This table summarizes aggregated data for mild, moderate and severe categories.

Figure 4 Percentages of participants who experienced mild, moderate or severe MSDs in the FHW and EHAW conditions

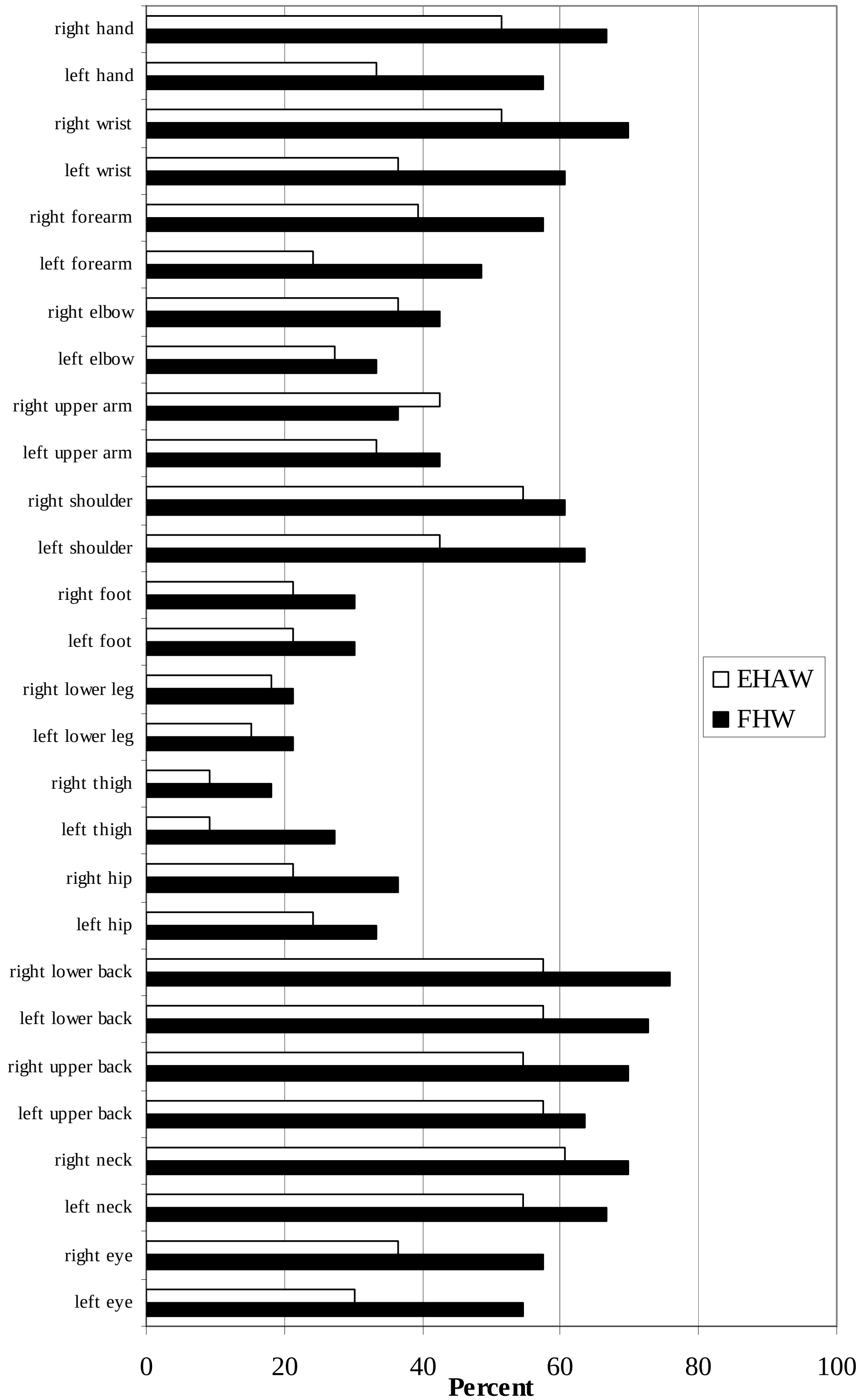


Table 4 Percentage prevalence of musculoskeletal discomfort symptoms rated as occurring monthly/weekly/daily for the FHW and EHAWs

	FHW	*EHAW*	Z	df	P
left eye	51.5	30.3	-2.056	33	0.04
right eye	54.5	36.4			ns
left neck	63.6	60.6			ns
right neck	69.7	60.6			ns
left upper back	60.6	54.5			ns
right upper back	69.7	54.5			ns
left lower back	63.6	51.5			ns
right lower back	72.7	60.6			ns
left hip	30.3	18.2			ns
right hip	34.4	18.2	-2.461	32	0.014
left thigh	21.2	12.1			ns
right thigh	15.2	12.1			ns
left lower leg	15.2	21.2			ns
right lower leg	15.2	21.2			ns
left foot	12.1	24.2			ns
right foot	18.2	27.3			ns
left shoulder	57.6	51.5			ns
right shoulder	63.6	54.5			ns
left upper arm	33.3	36.4			ns
right upper arm	36.4	48.5	-2.743	33	0.006
left elbow	30.3	36.4			ns
right elbow	42.4	39.4			ns
left forearm	39.4	30.3			ns
right forearm	54.6	48.5			ns
left wrist	57.6	42.5			ns
right wrist	66.7	57.6			ns
left hand	54.6	45.5			ns
right hand	66.7	51.5	-2.362	33	0.018

Figure 5 Percentages of participants who experienced monthly, weekly or daily MSDs in the FHW and EHAW conditions

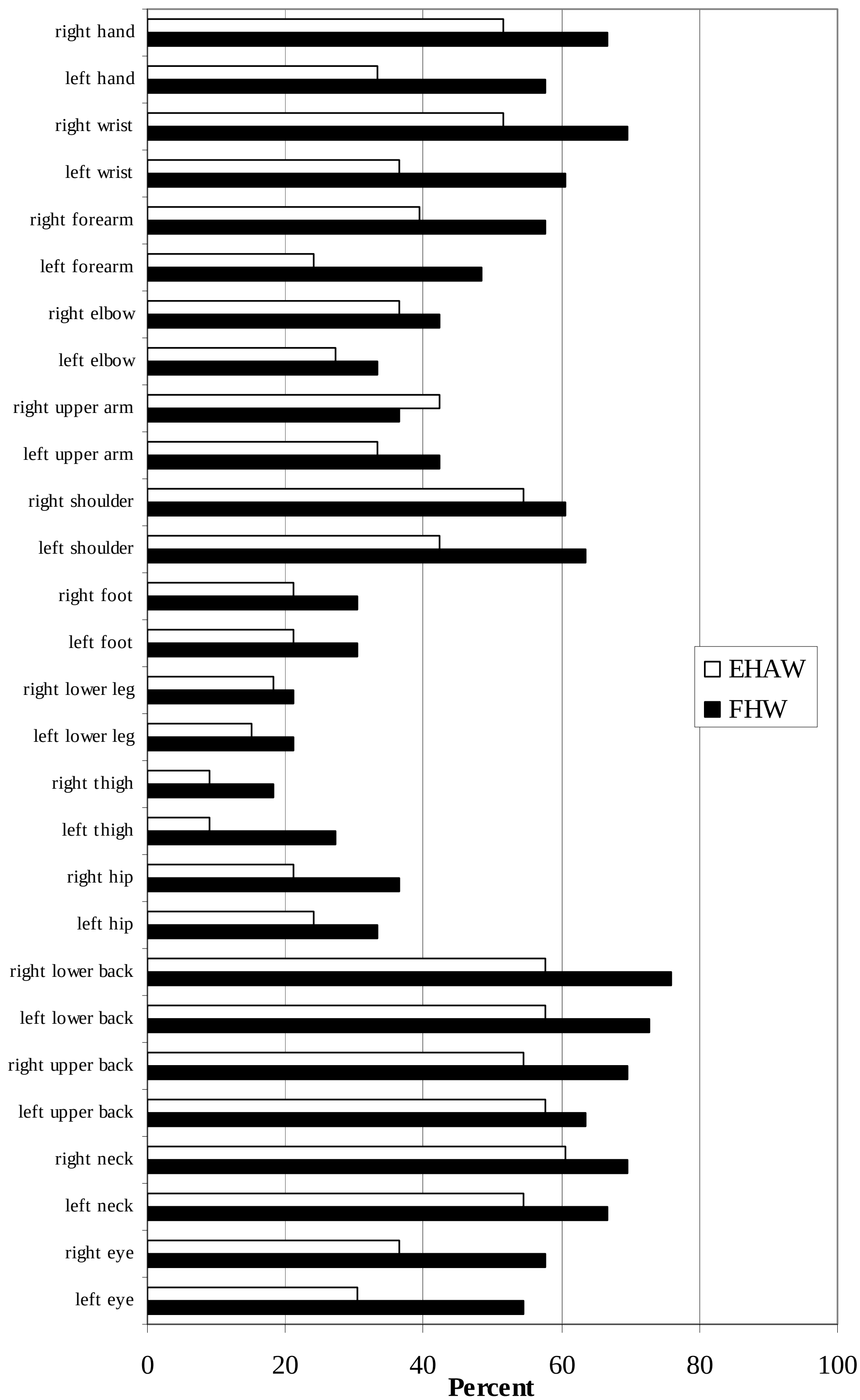
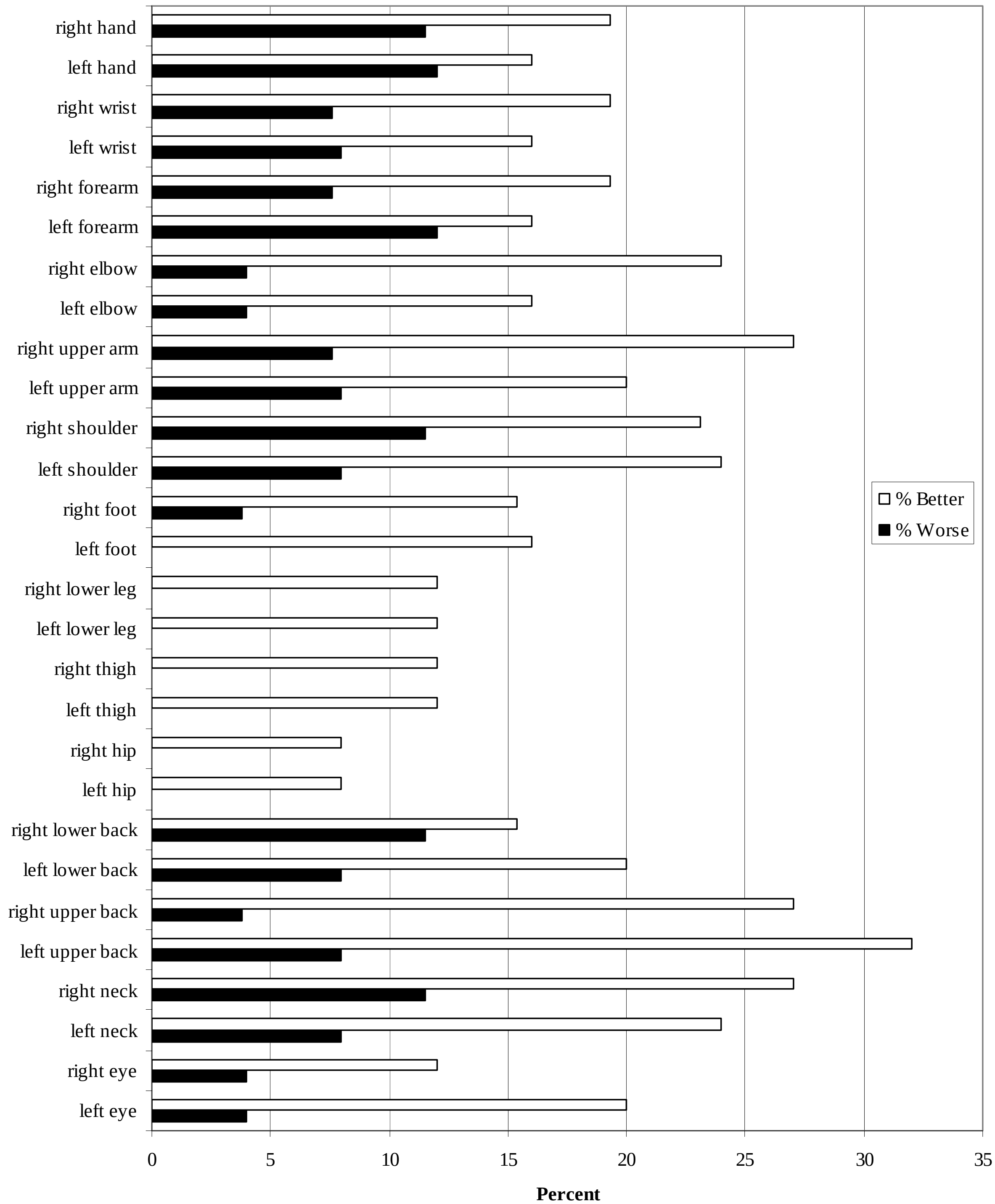


Table 5 Percent changes in the prevalence of musculoskeletal discomfort reports by body region of the participants after using the EHAWs compared with the FHWs

	% Worse	%No change	% Better
left eye	4	76	20
right eye	4	84	12
left neck	8	68	24
right neck	11.5	61.5	27
left upper back	8	60	32
right upper back	3.8	69.2	27
left lower back	8	72	20
right lower back	11.5	73.1	15.4
left hip		92	8
right hip		92	8
left thigh		88	12
right thigh		88	12
left lower leg		88	12
right lower leg		88	12
left foot		84	16
right foot	3.8	80.8	15.4
left shoulder	8	68	24
right shoulder	11.5	65.4	23.1
left upper arm	8	72	20
right upper arm	7.6	65.4	27
left elbow	4	80	16
right elbow	4	72	24
left forearm	12	72	16
right forearm	7.6	73.1	19.3
left wrist	8	76	16
right wrist	7.6	73.1	19.3
left hand	12	72	16
right hand	11.5	69.2	19.3

Figure 6 Percent respondents self-reporting positive or negative changes in musculoskeletal discomfort of the participants after using the EHAWs



3.6 Time-of-Day Discomfort Effects

For a typical work day, participants rated the degree of MSD experienced at different times using a scale from zero (no discomfort) through to 10 (maximum discomfort). There were no significant differences in the mean discomfort ratings at the start of the day and in late morning. Ratings were significantly lower for the EHAW condition for mid-morning and throughout the afternoon until the evening

Table 6 Time-of-Day and Mean Discomfort Ratings

	FHW	EHAW	df	Paired-t	P
Home morning	1.6	1.3	17		ns
Start work	1.8	1.0	17		ns
Mid-morning	2.8	1.9	17	2.12	0.049
Late-morning	3.4	2.9	17		ns
Early afternoon	4.0	3.1	17	2.20	0.042
Mid-afternoon	5.2	3.8	17	3.08	0.007
End work	5.7	4.2	17	3.62	0.002
Home evening	4.6	3.5	17	2.60	0.019

3.7 Comfort Ratings

Participants were asked to rate the comfort of their keyboard, mouse, chair and their workstation for each study condition during the previous 4 weeks on a 6 point scale (1=very uncomfortable, 2=fairly uncomfortable, 3=slightly uncomfortable, 4=slightly comfortable, 5=fairly comfortable, 6=very comfortable) and the results are shown in table 7. There were significant improvements in comfort ratings for the keyboard, mouse, chair, and workstation, and comfort was higher with the EHAWs. Figures 7, 8, 9 and 10 show ratings of comfort for the keyboard, mouse, chair and workstation comfort respectively.

Table 7 Mean Comfort Ratings for Workstation Components for the FHW and EHAWs

	FHW	EHAW	Z	df	P
Keyboard comfort	3.4	4.6	-2.90	30	0.004
Mouse comfort	3.2	4.2	-2.88	30	0.004
Chair comfort	3.2	4.4	-2.70	30	0.007
Workstation comfort	3.2	4.9	-3.92	31	0.000

Figure 7 Ratings of keyboard comfort for the FHW and EHAW conditions.

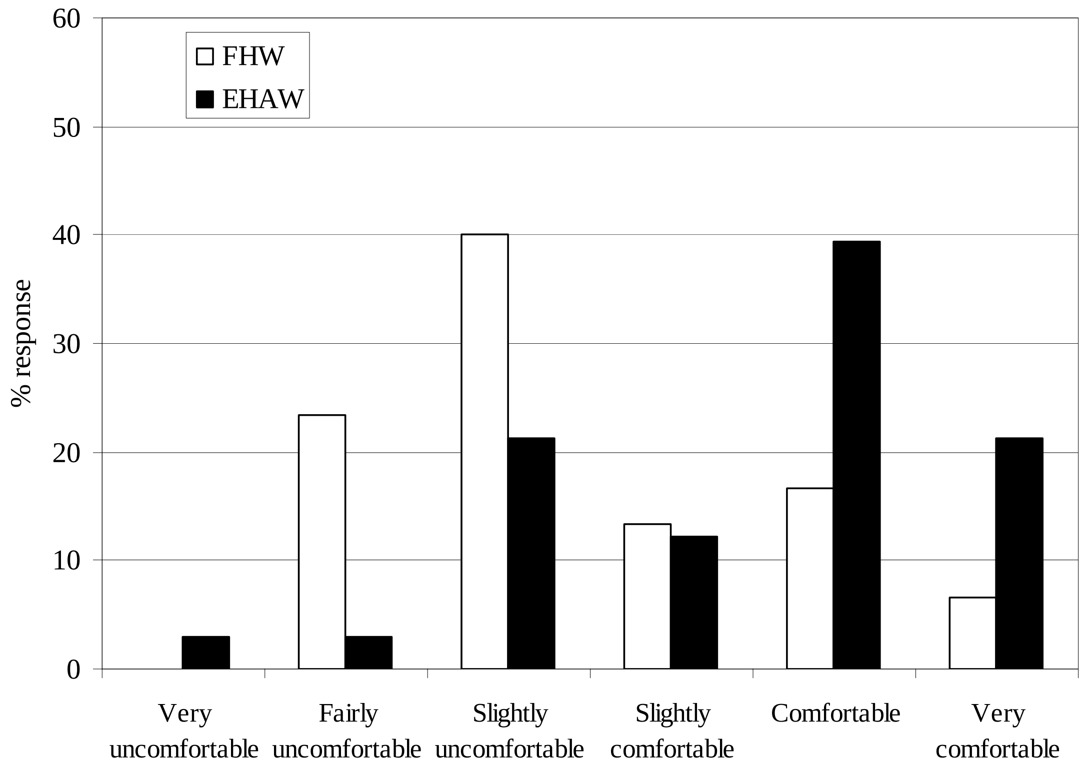


Figure 8 Ratings of mouse comfort for the FHW and EHAW conditions.

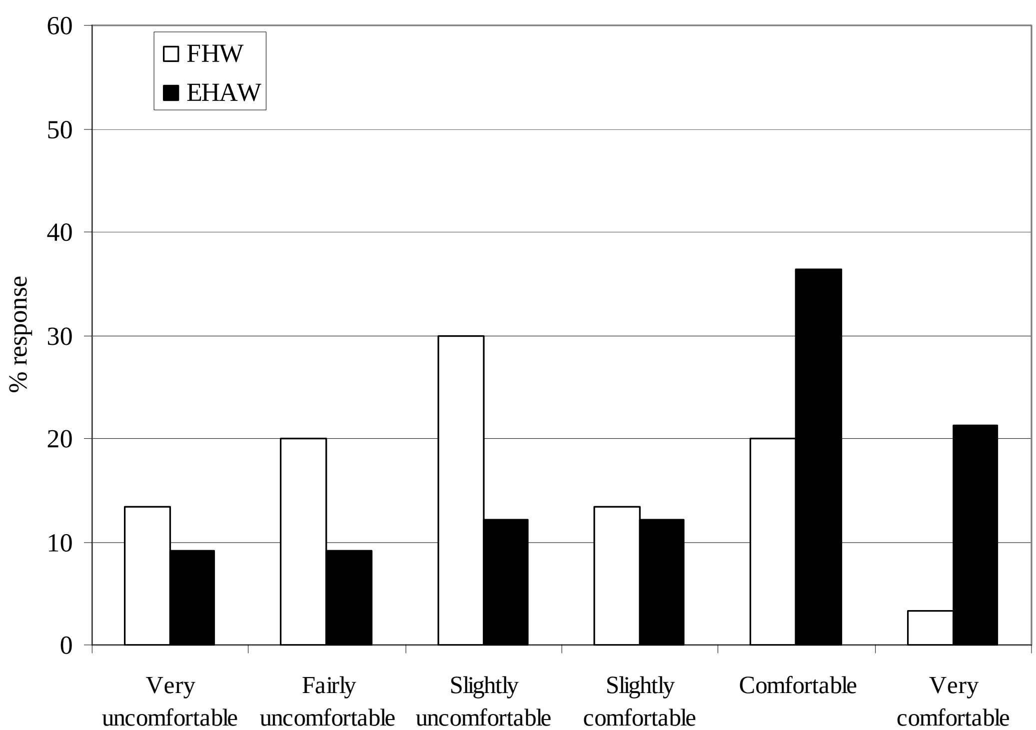


Figure 9 Ratings of chair comfort for the FHW and EHAW conditions.

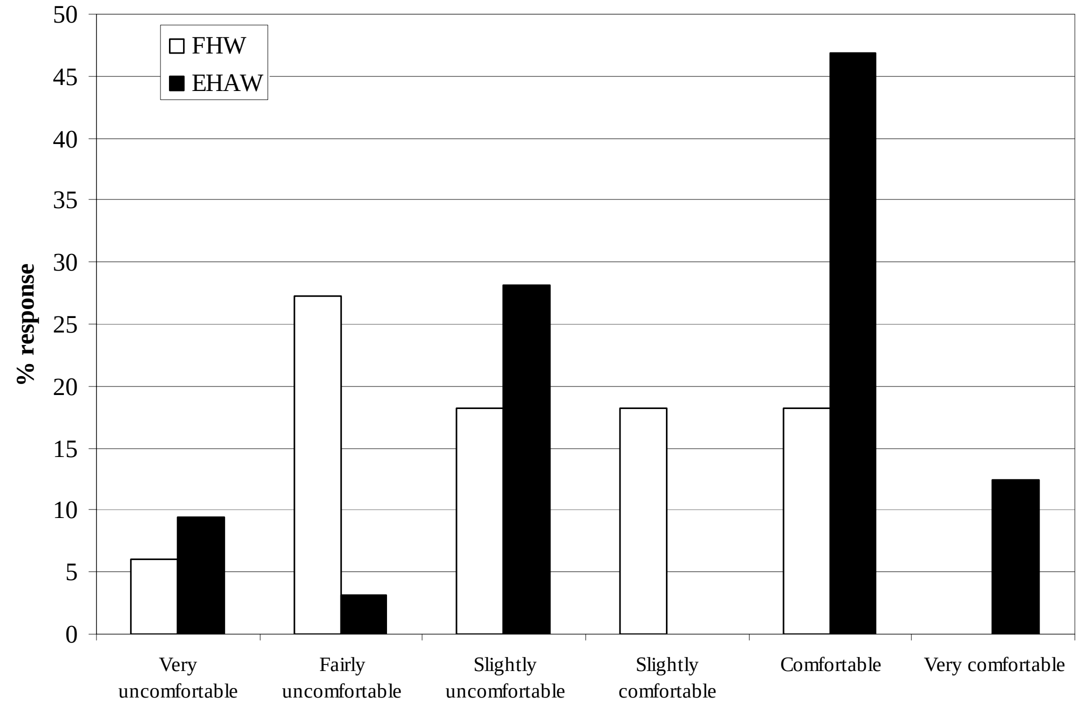
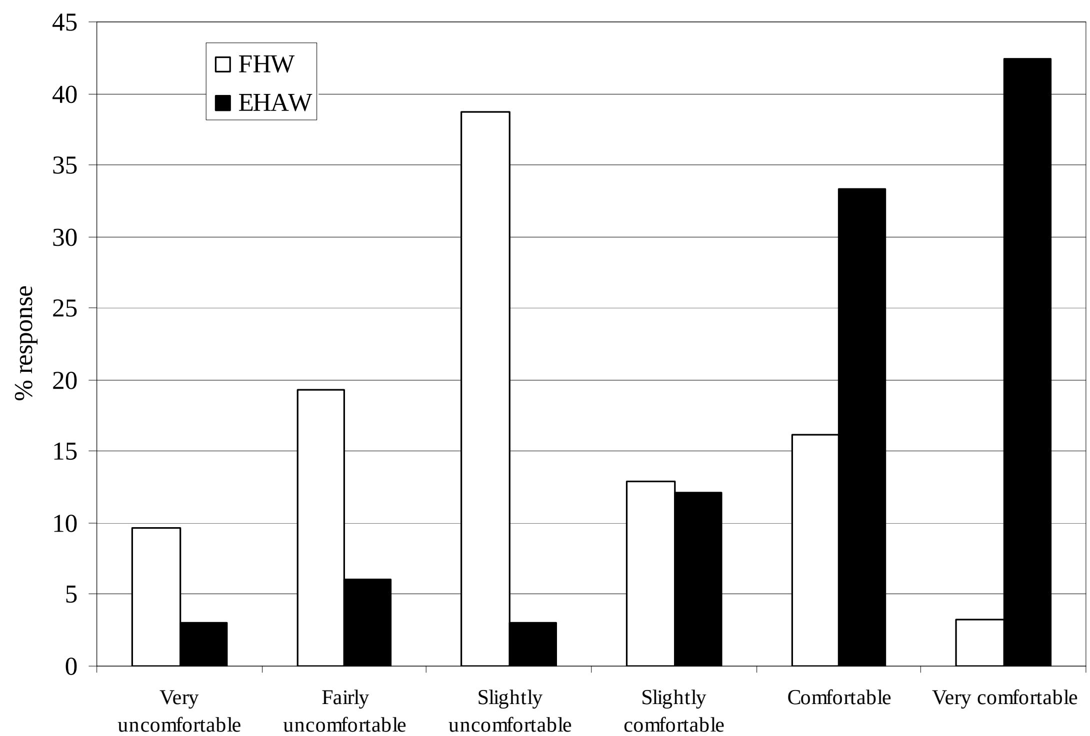


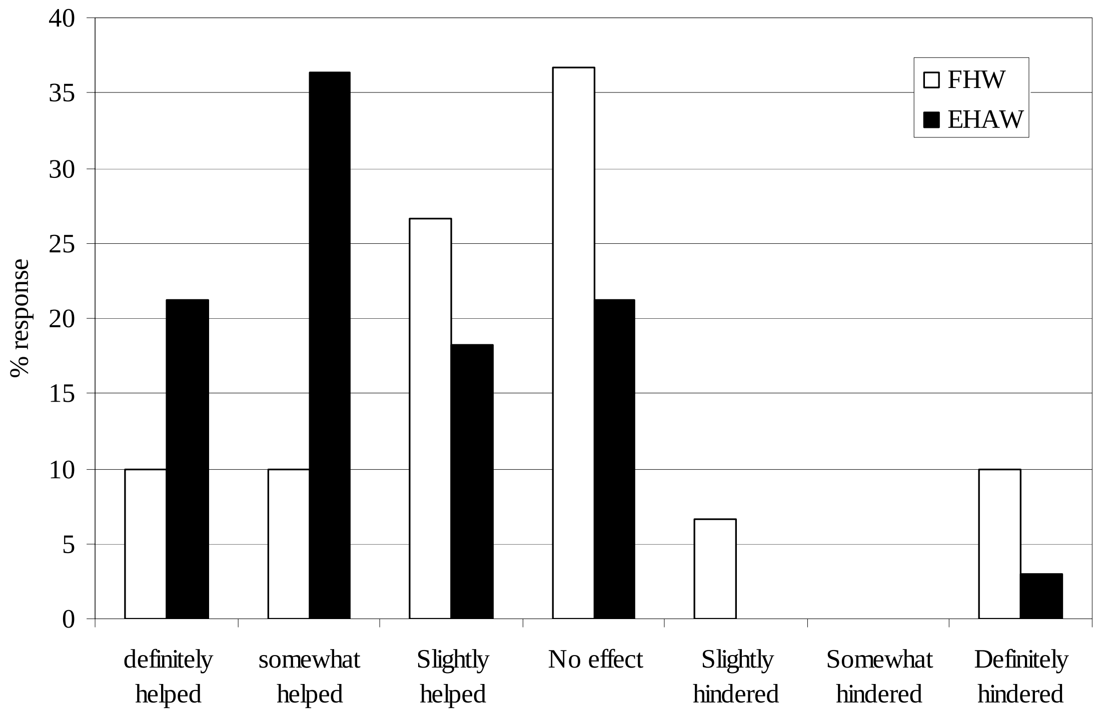
Figure 10 Ratings of workstation comfort for the FHW and EHAW conditions.



3.8 Productivity Ratings

Participants were asked to rate how much their workstation affected their productivity during the previous 4 weeks and the results are shown in figure 11. Productivity ratings for “somewhat/definitely helped” were significantly higher for the EHAWs compared with the FHWs (57.5% vs. 20.0%: Z(30) =-3.23, p=0.001). Most participants (82.4%) preferred the EHAW and 64.7% indicated a definite preference for this arrangement.

Figure 11 Self-reported productivity for the FHW and EHAW conditions.



3.9 Ease-of-use Ratings

Participants were asked to rate how easy it was to use each of three features of the control panel on their EHAW and the results are shown in table 9. All participants indicated it was easy to use the height adjustment buttons. A majority of participants (64.6%) said that it was easy to use the memory buttons, although a fifth of participants had not used this feature. A majority (90.4%) of the respondents said that it was easy to read the height display.

Table 9 Control Panel Ease-of-Use (percent responses)

	Extremely easy	Very easy	Fairly easy	Neither	Fairly difficult	Extremely difficult	Never used
up/down buttons	48.1	33.3	18.5				
memory button	18.5	22.2	33.3		3.7	3.7	18.5
height display	40.7	37.0	14.8	3.7			3.7

3.10 Location Convenience

Participants were asked to rate how convenient they found the location each of four features on their EHAW and the results are shown in table 10. Two-thirds of participants (68.2%) indicated that the control panel location was convenient, though some found this to be inconvenient for their needs. A majority of participants (72.7%) said that it was the height adjustment buttons and height display were conveniently located and 63.6% indicated that the memory buttons were conveniently located.

Table 10 Convenience of Location of Features (percent responses)

	Very inconvenient	Fairly inconvenient	Somewhat inconvenient	Neither	Somewhat convenient	Fairly convenient	Very convenient
control panel	7.4	11.1	11.1		11.1	25.9	33.3
up/down buttons	3.7	3.7	3.7	14.8	11.1	25.9	37.0
memory button	4.0	4.0	4.0	16.0	16.0	20.0	36.0
height display	3.7	3.7	3.7	14.8	7.4	25.9	40.7

3.11 Preference Ratings

At the end of the study participants were asked to rate their workstation preferences and the results are shown in table 9. Only one participant indicated a preference for the FHW workstation, mainly because they had experienced some problems with the stability of the installed EHAW and because they needed to have the whole of their workstation adjust in height, not just the corner worksurface that was installed. A large majority of participants indicated a preference for the EHAW (82.4%) and 64.7% indicated a definite preference for this arrangement.

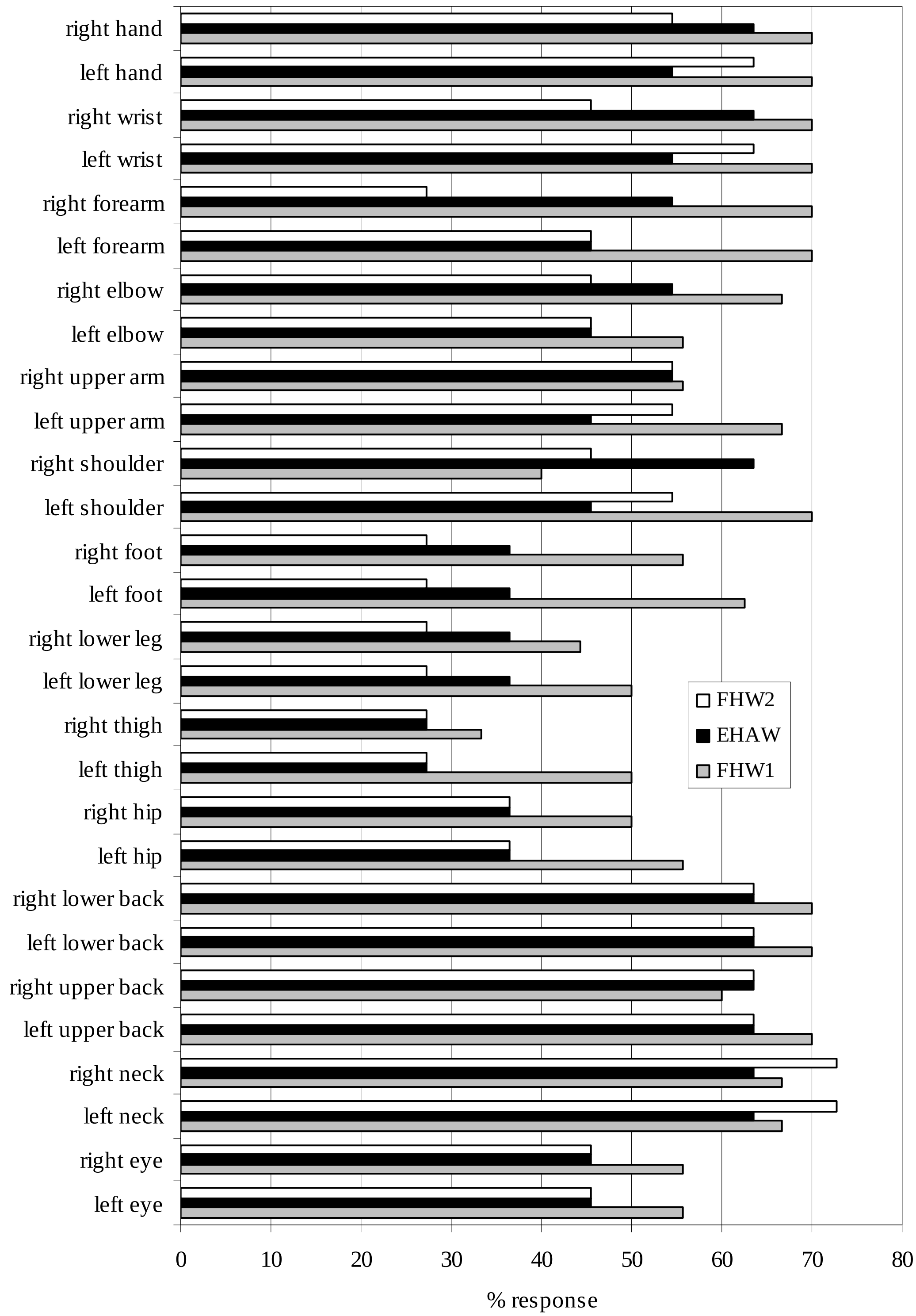
Table 9 Workstation Preferences

Definitely prefer FHW	3.7
Slightly prefer FHW	7.4
No preference	11.1
Slightly prefer EHAW	3.7
Somewhat prefer EHAW	7.4
Definitely prefer EHAW	66.7

3.12 Placebo Effects

Eleven participants completed the crossover design (FHW1-EHAW-FHW2) and their results were analyzed to evaluate a placebo effect (Figure 12). There were significant decreases in MSD symptoms in the right forearm (Z(10) = -2.06, p=0.039) and right wrist (Z(10) = -2.07, p=0.038) between FHW1 and EHAW conditions, but no other significant differences. There were no significant differences between the EHAW and FHW2, though the trend was in the expected direction. An attempt to assess any placebo effect met with limited success. Further studies are needed.

Figure 12 - Prevalence of MSD symptoms for FHW1-EHAW-FHW2 conditions.



3.13 Participants' Comments

The verbatim written comments made by participants are summarized in table 10. Most of the comments about the EHAWs were positive.

Table 10 Participant comments on the EHAWs

Fixed height work surface , gave a continuous counter space, and more shelf space.
I didn't spend much time on my adjustable height work surface.
I like the sit-stand configuration since it gives me the flexibility of standing up while typing. Also, it is easier for two people working and typing at the same time.
I didn't have any particular discomfort when I started using the adjustable height work surface, so this survey doesn't capture how very relaxed and comfortable I felt using it. I wasn't in pain before, but with this table my sitting and working posture felt good. Before, I would start wriggling in the afternoon-I stopped squirming in my chair with this adjustable height workstation. I'm sorry to give it back.
I definitely prefer adjustable height workstation. However, I had mechanical/electrical problems with the equipment. In the first week, the table got stuck in the stand position and would not go down. Guess the motor stopped working. The vendor took one week to correct the problem. I was standing all day for one week. This negatively affected my productivity. However, after the table was repaired, I was able to adjust height the way I needed. It helped my elbow, forearm and wrist.
As soon as I started to get any pain I adjusted the table height and the pain either went away or got better. This is very necessary for working long hours. Need to have the ability and flexibility to adjust table height during the day.
The adjustable height work surface really helps me to be more comfortable doing my work. I find that standing three to four times of day helps my neck and back (I usually stand for approximately 20 to 30 minutes at a time). This allows me to stretch and move while continuing with my work. I still take a few short breaks, but these are more to give my eyes a rest from the monitor. It was not real clear to me getting the workstation heights set initially; I figured it out, but to took a few minutes (the manual wasn't clear).
Good: Wider front opening that allows the armrest of a chair to move closer to the desk. The flexible height adjusting brings convenience whenever we need to discuss work on the screen. Also it allows me to stand up to stretch my back, and I often forget to use such setting. Bad: The height of the support metal ball underneath the table is slightly low. So my HP Unix's CPU box can't sit on the floor. It has to sit on top of my desk which is very noisy and it occupies too much room. Due to its height adjusting flexibilities, I would adjust the table height to make myself slightly comfortable when pain appears or later in the day, which generates more pain afterwards.
The varying heights definitely helped avoid "repetitive stress" in a big way.
Definitely better than fixed height work surface. Also helps me remember to take breaks and stretch and I need to adjust height.
My adjustable-height workstation had a severe problem: instability. When raised, the whole table would shake even when I typed, causing dizziness. I definitely prefer standing, but I will switch to a fixed-height standing desk.
Thanks for the adjustable worktable. It definitely changed the way I work. I wish I can keep it forever.
I'd like to keep it. It makes me so much better. My neck was suffering a severe pain, but after I got this table I am feeling much better now. Please let us keep it.

4.0 DISCUSSION

Results agree with previous research demonstrating beneficial effects of using height-adjustable worksurfaces. Participants reported standing for 21% of the day, which is comparable to the 23% reported by Nerhood and Thompson (1994). Use of the EHAWs resulted in significant decreases in the severity of MSD symptoms for most upper body segments. Discomfort ratings were lower by the end of the workday, which also agrees with previous research (Paul, 1995b). There were significant improvements in comfort ratings for all aspects of the furniture workstations with the EHAWs and participants reported improvements in their personal work productivity. There was almost a unanimous preference for the EHAWs rather than the FHWs. Most written survey comments were positive about the EHAWs and 3 participants refused to relinquish their EHAW during the study.

There was a relatively small effect of the EHAWs on MSD symptom frequency. This may be a result of the relatively short duration of the test period (4-6 weeks).

5. CONCLUSIONS

The results of this study suggest that there may be a number of benefits associated with using the EHAWs. Apart from some minor increases in the frequency of experiencing some musculoskeletal discomfort, there were substantial decreases in the severity of many upper body MSD symptoms after working at the EHAWs. These changes occurred over a relatively short timescale of 4 to 6 weeks which suggests that the potential benefits may be even greater after longer time periods of use. There were significant improvements in comfort ratings for all aspects of the furniture workstations with the EHAWs , and there was almost a unanimous preference for the EHAW arrangement. A majority of the written comments on the surveys also supported this view. Exploration of the longer-term impact of EHAWs on MSD symptom frequency is needed.

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