The productivity benefits of office ergonomics interventions

A review of the current literature

Wellnomics® White Paper

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Introduction

The widespread interest in decreasing the incidence of, and costs associated with, musculoskeletal discomfort and disorders has led to many intervention studies. These studies typically compare measures of discomfort or disorders prior to the application of a particular intervention (e.g. alternative keyboard, additional breaks, exercise programs, alternative work desks or training) and then re-measure the levels of discomfort, and other outcome measures, following the invention. Some intervention studies also include measures of productivity when comparing 'before' and 'after' states. The effect that interventions have on productivity is likely to be of great interest to organizations with respect to the potential cost-benefit, both in terms of investment spent on interventions to prevent and manage discomfort and disorders, and the potential productivity effects of the interventions.

A literature search was performed to identify peer reviewed journal articles that reported on interventions that were designed to improve the musculoskeletal health of computer users and that also reported on an aspect of productivity, for example, sickness absence, error rates or output or included some form of cost-benefit assessment. The following summarises examples of these studies by intervention type published from 1994 to April 2008.

Rest Breaks

Kopardekar & Mital (1994)[1] considered the rate of errors (words misspelled or corrections made using the backspace key) with respect to different work-rest schedule conditions. They found that work-rest schedules were a critical factor in performance and that when the continuous working duration was increased from 60 minutes to 120 minutes the amount of errors recorded increased by almost 80%. This showed that five minutes break after 30 minutes of work and a ten minute break after 60 minutes of work resulted in a better performance than 120 minutes of continuous work.

Henning et al (1997)[2] used the number of claims processed from company records as a productivity measure to compare no additional breaks with four short breaks (three 30-second and one three-minute break) every hour. The study took place at a two work sites with a large and a small group. In the final stage of the study exercises were performed during the breaks. Productivity was found to increase with both breaks and breaks and exercise at the smaller site with no change noted at the larger site. The authors concluded that frequent, short computer breaks can benefit both operator well-being and productivity when the breaks integrate with task demands. Importantly, adding breaks and thus decreasing work time did not adversely affect productivity. Similarly, McClean et al (2001)[3] found no evidence of detrimental effect on worker productivity with the introduction of breaks in an experimental setting. The participants in this study were assigned to conditions of control (they took breaks as they wished), a break of 30-seconds after 20 minutes of work and a break of 30-seconds after 40 minutes. Productivity was measured by the number of words (five keystrokes) typed. They found that the breaks reduced discomfort in all areas (neck, back, shoulder, forearm and hand) and in particular when breaks were taken at 20 minute intervals.

The benefit of breaks without reducing productivity was also found in a NIOSH study in 2000[4]. The study was conducted at a data-entry operator worksite and operators were randomly assigned to either a 'supplementary' break or 'usual' break schedule which was then reversed after four weeks. The 'usual' break schedule was 15-minute breaks after 2 hours and 6.5 hours of work and a 30-minute break after 4 hours of work, the supplementary break schedule provided additional 5-minute breaks after 1, 3, 5.5 and 7.5 hours of work. Productivity was measured through company records and included keystrokes per hour, total number of documents processed per day and accuracy (errors per day and daily accuracy percentage). The varying rest break schedule had no effect on these productivity measures and there was less discomfort, less eye soreness and less visual blurring reported with the supplementary break schedule. The authors emphasised that

> *'…the supplementary rest break schedule did not have any negative impact on worker performance. Furthermore, interviews with worksite manager indicated that no disruption of work processes were (sic) associated with the supplementary rest break schedule …and all the productivity goals were met on schedule…' p 636*

The authors repeated the study again (Galinsky et al, 2007[5]) and similar results were found. The mean ratings of musculoskeletal discomfort and eyestrain symptoms were significantly lower when the participants worked under the supplementary schedule than when they worked under the conventional schedule. Productivity measures recorded by the employer of computer use duration, total documents entered per day and keystrokes per hours were not significantly different between break schedules. These results were in spite of an increased amount of non-entering time of an average of 19 minutes. Performance was maintained by an increased data entry rate in the schedule with more breaks.

Balci & Aghazadeh (2003)[6] also used keystroke rate and errors as a measure of productivity when rest breaks schedules were varied. The schedules they tested were

1. 60-minute work /10-minute rest
2. 30-minute work /5 minute rest
3. Three 30-seconds breaks and one 3-minute break during one hour of work in addition to a 14 minute break after two hours

They found that the third schedule with more frequent breaks resulted in the highest speed and accuracy for both data entry and mental arithmetic tasks. This schedule was also found to be superior in terms of discomfort in the upper extremities than the other break routines.

van den Heuvel et al (2003)[7] used odometer software (Wellnomics® WorkPace®[8]) to stimulate workers who had work-related complaints in the neck, shoulders, arms, wrists, hands or fingers for at least two weeks to take regular breaks or to take regular breaks and perform exercises over a three-month period. They then examined the effects on perceived overall recovery from complaints, frequency and severity of complaints, self-reported sick leave, mean number of key strokes per day and error rates (the number of backspace and delete key uses) and a comparison was made with a control group. The results showed that the break groups recovered better from complaints and reported less deterioration of symptoms. There was no difference in frequency and severity of complaints or sick leave amongst the three groups. The number of keystrokes was significantly higher in the 'breaks only' group and accuracy rate was higher in both break groups than in the control group.

In summary, there is good evidence that frequent rest breaks improve productivity and the extra non-work time associated with more breaks does not detrimentally affect productivity. Frequent rest breaks also provide benefits of reducing musculoskeletal and visual discomfort for computer users. Galinsky et al (2007)[5] concur with this and assert that

> *'Taken together with similar results from eight previous studies, this recurring outcome provides convincing evidence that productivity concerns should not prevent managers from considering frequent rest breaks for workers in computer-intensive jobs' pg 525*

Work Equipment Adjustments

Whilst many studies have measured the effect of various changes in workstation set-up or different input devices most have not reported on specific productivity outcomes, focussing instead on changes in levels of reported discomfort. However, Swanson et al (1997)[9] included measures of data entry performance, Aarås et al (2001)[10] included musculoskeletal sick leave amongst their recorded outcomes and DeRango et al (2003)[11] more comprehensively considered productivity outcomes in a chair and training interventional study.

Swanson and colleagues (1997)[9] considered how 'alternative' keyboard design impacted on performance measured by keystrokes and errors per hour. They found no significant productivity differences between keyboards after two days of exposure. There were also no differences in comfort or fatigue between different keyboard designs.

Aarås and his team considered what effect the provision of an upright mouse had on the development of pain compared to a standard mouse amongst participants who already complained of pain. The results with respect to musculoskeletal sick leave varied between the parallel intervention groups from no significant change to a reduction from an average of 3.1 days to 0 days in a six month period.

While these studies recorded some productivity measures they were not the primary focus of the studies. This is in contrast to the study by DeRango et al (2003) who specifically designed a study to assess the productivity effects of interventions in an organization. The interventions were delivered to two groups and one group was a control. One intervention group received a highly adjustable chair and training in office ergonomics whilst the other group received only the training and was taught to adjust their existing chair. Reports of pain were collected repeatedly using the two-item bodily pain scale from the SF-36[12]. Productivity measures were provided from data collected by the organization and were sales tax collections ($) per effective workday. Sick leave data as hours per month was also collected. The researchers examined the effect of the interventions on total productivity and on a health mediated model whereby the effect of pain on productivity was estimated. This allowed investigations of the improvements in productivity which were associated with improvements in pain scores which are less likely to be affected by the Hawthorne effect[13].

Whilst they found that there was no significant effect of the interventions on sick leave hours they found that the 'chair with training' intervention improved overall productivity and that this improvement was sustained during the 15-month study period. The chair-with-training intervention also significantly reduced pain reports at a magnitude of approximately 9 to 10 % (5.95 to 6.23 points). When these improvements in pain scores were considered alongside productivity data it was found that a one-point improvement in pain was associated with an improvement of productivity of between $13 and $19.

Using a pre-intervention per day productivity figure the calculated increase in productivity is 17.7 % for the total effect and 6 % for the health-mediated model for the group that received the intervention of a fully adjustable chair and training in office ergonomics. Considering the cost of the intervention of the chair-with-training (cost of chair, direct and in-direct training costs) and the average salary of employees and the productivity benefits seen with the intervention yields a benefit-to-cost ratio of approximately 25. The authors state:

> *'In other words, benefits from the chair-with-training intervention are approximately 25 times larger than costs in the first year.' p 16*

They go on to also comment that when the marginal product of labour is closer to the wage rate then

> *'… the daily benefits of the chair-with-training intervention can be approximated by multiplying the percentage increase on-the–job daily production by the wage rate. ..Taking the wage rate and number of days worked per month from the study above, the benefit-to-cost ratio after the first year would be 2.13. Thus, the lower productivity gain estimates from the health-mediated model imply that the 'chair-with-training intervention' would pay for itself within six months…' p 16-17*

This study was replicated in the private sector[14] and showed similar reductions in symptoms in the group receiving the chair with training. Unfortunately, no productivity outcomes were reported.

Smith & Bayehi (2003)[15] also looked specifically at productivity outputs from company records and found improvements with three stages of interventions including training and the provision of workstation accessories and a fully adjustable chair. The productivity of the groups receiving the interventions increased on average by 4.87 % while the productivity of the control group decreased 3.46 %. The total output for each ergonomics improvement was higher after the intervention from between 2.4 % and 9.4 % compared to a decrease of 3.1% in the control group. The researchers concluded

> *'Improved ergonomics of various types led to modestly higher output from pre to post intervention, and a benefit greater than a control group not receiving ergonomics improvements' p 16*[15]

The authors also performed a cost-benefit analysis and found that depending on the type of intervention there was a one to five month payback on the investment in ergonomics improvements.

Productivity was studied as an adjunct to a randomized controlled study in a call centre (Rempel et al, 2006[16]) which compared the effects of training with provision of a trackball and training with a provision of a trackball and large forearm support on upper body pain and musculoskeletal disorders. The employer-tracked measures of productivity included percentage of time available for calls average call handling time and calls per hour. Participants were also asked to rate their own productivity. No significant differences were found between intervention groups for any of these measures. This was despite a significant effect on reduction of neck/shoulder and right upper extremity pain and a preventative effect approximately halving the risk of neck/shoulder disorders when the forearm support was used compared to training alone. No significant effects were found for the use of the trackball. No analysis was performed on the productivity data for individuals whose pain was reduced.

The authors also conducted a return on investment calculation for the provision of the forearm support and the cost savings associated with preventing neck/shoulder disorders. They found that, based on only accepted compensation claim costs (medical and salary), the pay back time was 10.6 months. This calculation is likely to be conservative since it did not take into account the indirect costs such as staff replacement, re-training, attrition or the benefits of symptom improvement for those who do not make claims or whose claims are not accepted.

In summary, some workstation equipment changes, particularly a fully adjustable chair, in combination with other interventions (e.g. training) seem to have a positive effect on the productivity of workers and help to decrease discomfort whilst sickness absence is generally unaffected. The cost-benefit estimations for specific interventions are very favourable.

Training

Training has been included in most of the workstation intervention studies outlined above[11, 15, 16]. The effect on productivity of a type of training was also considered by Henning et al (1996)[17]. They provided one group of VDU users with continuous on-screen feedback about whether or not sufficient breaks had been taken and no feedback to another group to examine if the feedback had an effect on discretionary break schedules. They found that typists receiving the feedback were able to improve their self-management of breaks. They found also that productivity, measured by keystrokes, errors and correction rates, were unaffected by the provision of the feedback.

Lewis and colleagues (2001) firstly implemented an ergonomics training program for computer users[18] and then assessed its effectiveness [19](Lewis, et al, 2002) in terms of workers compensation costs and injury rates for musculoskeletal disorders associated with computer use before and after the training program. They found that whilst the number of claims was higher following training the costs of the claims were much less than in the pre-training period and the average injury rate per 1000 employees was less. The outcome measures did not take into account the indirect costs of injuries, for example administrative costs and lost productivity, so the true costs and therefore the potential benefits are likely to be underestimated. The authors conclude

> *'Programs that provide employees with the necessary ergonomics knowledge and skills regarding proper workstation setup may be effective in reducing the injury rates and costs associated with those injuries.' p 95*

In summary, training, particularly in combination with other interventions, has a positive effect on productivity and is likely to have financial benefits for an organization. On-screen training regarding breaks is not detrimental to productivity.

Wellness

Some investigators have taken a broader approach to the management of musculoskeletal and visual discomfort and considered the role that general wellness factors, in particular physical exercise, may play in improving productivity. Daum et al (2004)[20] investigated, in an experimental setting, the effect that mis-correction of vision had on productivity. Productivity was measured as the time it took to complete a computer-based visual task and the number of errors. They found that even small mis-corrections of 0.5 diopters[21] affected the time to complete from 2.5 % to 28.7 %. They calculated a cost-benefit ratio of at least 2.3 for appropriate visual correction using an overall 2.5 % increase in productivity as an estimate and at a salary of $25,000.

Klemetti et al (1997)[22] reported that a controlled intervention of physical training amongst office workers with chronic neck tension did not change sick leave frequency six months following the intervention. Those in the intervention group, however, did increase their physical exercise and the frequency of relaxation and stretch exercises compared to the control group. The effect of a self-paced walking program was examined by Low and colleagues (2007)[23] in a small (n=32) sample of office workers who acted as their own controls. They measured productivity using the Endicott Work Productivity Scale[24] and found no differences between before and after intervention scores although blood pressure was reduced and weight loss was promoted. Blangsted and colleagues (2008)[25] considered the impact of various physical activity programs on sick leave and work ability of office workers. Mean sick leave was low (5 days per year) and work ability high (90 %) at baseline so unsurprisingly no changes were seen on these measures following the interventions. However, the duration and intensity of neck and shoulder symptoms were lower in the intervention groups than the reference groups at the one year follow up.

Viljanen et al (2003)[26] randomly assigned a group of office workers with chronic non-specific neck pain into intervention groups of dynamic muscle training, relaxation training and ordinary activity (as a control group). As minor outcome measures they asked the sample about work ability and if work was limited by pain and they also examined sick leave rates due to neck pain. No significant differences were found between the groups at follow up of three, six and twelve months.

In summary, while it appears to improve health measures, physical training does not have a measurable effect on productivity outcomes or sickness absence. Optimal visual correction, on the other hand, has been shown to be important in optimising productivity and shows a strong cost-benefit.

Literature Reviews

While not specifically limited to assessing productivity measures some reviews of the literature have endeavoured to ascertain if ergonomics interventions are effective in controlling musculoskeletal disorders. In 2001, Karsh et al[27] conducted a literature review of published ergonomics interventions used to control musculoskeletal disorders in workplaces. The workplaces that were studied were in a variety of non-agricultural industries including office workplaces. They found that 84 % of the studies that met the selection criteria found some positive results, with most having mixed results. The most effective were multiple component interventions where 97 % led to at least some improvement in outcomes. They concluded

> *'The overall results clearly support the position that engineering, administrative and person-focused interventions can be effective in reducing WMSDs.' p 86*

They go on to suggest that the implementation of ergonomics interventions should follow the guidelines that have been successful in safety management.

> *'These guidelines include having top management commitment, employee participation in design and implementation, training, a formal programme structure with designated leaders, and formal lines of communication to discuss issues and problems that arise.' p 87*

In a similar review of ergonomics intervention studies that aimed to improve musculoskeletal health in the workplace, Westgaard & Winkel (1997)[28] found that interventions which actively involve the worker, for example, medical management of workers at risk, physical training or active training in work technique or combinations of these approaches) often achieve positive results. They conclude that this type of intervention strategy, along with organizational culture interventions with high commitment of stakeholders using multiple interventions, have the best chance of success. They suggest that these two strategies have the same overall approach:

> *'identifying and dealing with risk factors relevant for the individual at risk. Accordingly, the active support and involvement of the individual at risk and other stakeholders in the organization should be ensured' p 492*

In summary, multiple interventions including equipment, administrative and person-centred strategiies with a high commitment from stakeholders are most likely to be effective at improving musculoskeletal health in the workplace. In addition, it is important to identify risk factors for individuals and manage these risks in collaboration with individuals and organizational stakeholders

Summary

1. Specific interventions to prevent and manage musculoskeletal disorders generally have positive effects on productivity.
2. Frequent rest breaks can improve productivity and reduce discomfort.
3. Training and workstation equipment improvements can improve productivity with positive cost-benefit ratios.
4. Wellness interventions do not appear to have a measurable effect on productivity.
5. Sickness absence is not a sensitive measure for effective interventions in computer users.
6. Multiple workplace interventions based on identified risk factors with high stakeholder commitment are the programmes that are most likely to succeed and provide strong productivity benefits for the organization.

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