

# ERGONOMIC CHAIR INTERVENTION: EFFECT ON CHRONIC UPPER QUADRANT DYSFUNCTION, DISABILITY AND PRODUCTIVITY IN FEMALE COMPUTER WORKERS

## ABSTRACT

**AIM:** To compare the effect of two ergonomic chairs on upper quadrant musculoskeletal pain and tension, disability and productivity among female computer workers in the office workplace.

**METHODS:** A series of two N=1 studies were conducted using the A-B-A-C-A design whereby an intervention ergonomic chair was compared to a less adjustable control ergonomic chair using visual analogue scales (VAS) for pain and muscle spasm, the Neck Disability Index and the Work Productivity and Activity Impairment questionnaire. The female participants were assessed over the four week phases as they performed high intensity visual display unit work. The results were compiled and tabulated.

**RESULTS:** Both the control and intervention ergonomic chairs showed a reduction in both the mean and variance of pain and muscle spasm. The second participant also showed an increase in productivity with both chairs.

**CONCLUSION:** The introduction of an ergonomic chair shows a reduction in VAS intensity and frequency for pain and muscle spasm, as well as a reduction in variance of the symptoms. Both chairs showed a similar reduction in symptoms, thus indicating almost equivalent benefit from the use of both ergonomic chairs.

**KEYWORDS:** ERGONOMIC CHAIR, UPPER QUADRANT PAIN AND SPASM, DISABILITY, PRODUCTIVITY, OFFICE WORKERS

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## INTRODUCTION

Physiotherapists are often consulted for advice regarding computer workstations and the use of ergonomic office chairs to improve posture and musculoskeletal pain (Nakazawa et al. 2002). Upper quadrant musculoskeletal symptoms in the working population who use visual display units (VDU) are increasing and may be as high as 74 cases per 100 persons (Lindegard et al. 2012). Recommendations are usually supported by anecdotal evidence (Brewer et al. 2006, Westgaard, Winkel 1997, Wærsted, Hanvold & Veiersted 2010).

The International Ergonomic Association defines ergonomics as “the application of theoretical principles and methods of design in order to optimise human health and performance by understanding the interaction between human beings and other elements in

their system” (International Ergonomics Association 2011). An ergonomic chair is one which has been designed in order to improve the performance of its user. The designs aim to reduce the stress on musculoskeletal structures and thus assist with the management and prevention of symptoms and disorders which result from prolonged sitting (Juil-Kristensen et al. 2006). Various ergonomic chair features are suggested to aid the user: adjustable height, adjustable back support, castors with a wide base of support, curved seat pan, arm rests (adjustable or fixed), cushioning and the comfort of the chair (European Agency for Safety and Health at Work 2005). However, research to affirm these features is inconclusive (Van Niekerk, Louw & Hillier 2012).

Studies into the effectiveness of ergonomic interventions for musculo-

skeletal symptoms evaluate combined interventions and rarely research the benefit of the chair alone (Brewer et al. 2006, Kennedy et al. 2010). A review by van Niekerk et al (2012) showed a trend supporting the use of ergonomic office chairs to reduce upper quadrant muscle activity as well as a reduction in the intensity of the symptoms, although the chair was not the sole intervention in some of the studies reviewed. Only one study included office workers (Van Niekerk, Louw & Hillier 2012). The supposed effect of the chair on the sub-

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ject's symptoms may be due to the effect of the known contributors to the development of upper quadrant work-related musculoskeletal disorders (UQWMSD). These physical stressors are:

- Prolonged sitting or static postures (Griffiths, Mackey & Adamson 2007) {{51 Griffiths, K.L. 2007; 403 Nakazawa, Tetsuya 2002}};
- The duration of computer usage (Nakazawa et al. 2002);
- The position of the body in relation to the work space (Nakazawa et al. 2002, Griffiths, Mackey & Adamson 2007)
- Keyboard height in relation to the user where the keyboard is higher than the height of the elbow or elbow flexion is greater than 121° (Marcus et al. 2002)
- Forward head-on-neck posture where the head is 20% more flexed than neutral (Prins 2008)

Sitting discomfort and incorrect chair height have also been shown to influence musculoskeletal symptoms (Lindegard et al. 2012, Yu, Wong 1996). Gender is another risk factor for UQWMSD with women at greater risk (Hoy et al. 2010) and being more likely to develop recurrent or chronic symptoms (Janwantanakul et al. 2008). These factors, including the cost of the chair, are considered when a new chair is considered by office workers.

The aim of this study was therefore to assess the effect of a fully adjustable ergonomic intervention chair against a less adjustable, cheaper ergonomic control chair in women with upper quadrant symptoms and who perform high load VDU work. The hypothesis was that the more adjustable and more expensive chair would have a greater impact on upper quadrant musculoskeletal symptoms than the less adjustable and less expensive chair, but that both chairs would show an improvement in the selected outcomes.

Two chairs were compared to the subject's own office chair; the intervention ergonomic chair with adjustable back support, height and arm support, and the control ergonomic chair with only adjustable height and back support and which was a third of the cost of the intervention chair.

## METHODOLOGY

Ethics approval was obtained from the Health Research Ethics Committee at the University of Stellenbosch (N11/11/325) and each participant provided signed informed consent.

**Table 1: Features of the intervention and control ergonomic chairs as used in the study.**

Features of ergonomic chairs	Intervention chair	Control chair
Padded	√	√
Mid-back	√	√
Five star castor base	√	√
Height adjustable	√	√
Angled and contoured lumbar support	√	√
Height adjustable armrests	√	X
Moulded waterfall edge seat	√	√
Adjustable inclination of backrest	√	√
Adjustable resistance of the backrest	√	X
Cost	2.5x	x

## Study design

A single subject, N=1, randomised, A-B-A-C-A design study was conducted with two participants. N=1 studies require the symptoms to be long standing and stable. Each of the five phases lasted four weeks. It was hypothesised that the more adjustable intervention ergonomic chair (see table 1) would have a greater effect on reducing pain, muscle spasm, disability and productivity, compared to the control ergonomic chair with fewer adjustable features.

During *Phase A1* (initial baseline) the subject used her usual office chair.

During *Phase B* (the first intervention phase), the subject either used the intervention or control ergonomic chair. The randomisation of the chair for *Phase B* was done using an online random number generator by one of the researchers (R1). The random allocation sequence was placed in numbered opaque envelopes and given to another researcher (R2) who was contacted by the researcher (R3) after the subject was enrolled into the study to reveal which chair should be allocated during *Phase B*. Participants remained masked to the intervention as both the intervention and control chairs were new and similar in design.

*Phase A2* was the first washout phase and the subject used her usual chair, followed by *Phase C*, when either the control or intervention chair was administered, depending on which chair was provided in *Phase B*.

*Phase A3* was the second wash-out phase with the subject using her usual office chair.

## Subject description and recruitment

Female office workers aged between 25 and 50 years were recruited. They were full

time employees working on a computer for five to eight hours per day, Monday to Friday. The subjects had a minimum two year history of similar employment and a history of neck and/or shoulder pain for a minimum of three months. The subjects attributed their pain to sitting or their work environment.

Subjects were to be excluded if there was a presence of neurological signs or symptoms in the upper and lower quadrants, or if they had previous spinal surgery or trauma, malignancy or pathology which may contribute to their pain and perceived disability of their upper quadrant. Current or planned pregnancy was an exclusion criterion as there is an influence on body anthropometry (Yu, Wong 1996) as well as influencing the ability to be eligible for the study duration. The presence of forearm, wrist and hand symptoms deemed the subject ineligible as this is a result of typing as opposed to sitting (Slot et al. 2009). Being classified as having a high risk of yellow flags as calculated on the Örebro Musculoskeletal Pain Questionnaire (OMPQ) was an exclusion criterion. A total of 105 or more for the OMPQ indicates an increased risk of psychosocial factors influencing disability, perceived pain and outcomes (Hagberg, Tornqvist & Toomingas 2002). Body mass over 100kg excluded the subject as this is the maximum weight capacity for the intervention ergonomic chair.

Subjects were recruited from legal firms, university administration divisions and accountant and brokering companies via emails to the human resources departments. An email inviting possible participants was sent by the Human Resource departments to employees.

Eligible subjects were screened by the principal researcher by performing a subjective and objective evaluation. The physical examination was conducted

according to Neuromusculoskeletal Examination and Assessment (Petty 2011) at their place of work.

A work station assessment was conducted according to the European Agency for Health and Safety at Work (European Agency for Safety and Health at Work 2005). A workstation that did not comply with these standards made the candidate ineligible for the study. This eliminated other work station and ergonomic factors which may influence the upper quadrant symptoms. These factors were:

- lighting and noise interference;
- mouse and keyboard position and adjustability;
- desk height and position;
- computer position; and
- screen adjustability.

Factors which are not within the accepted ranges have been shown to adversely influence UQWMSD and thus may interfere with the results of this study. The only workstation intervention by the researcher was to provide a foot rest to the participants for the full duration of the study if it was deemed necessary for correct chair set up (Helander, Rupp 1984). This ensured correct elbow height and maintained foot contact with a solid surface as per the guidelines of the European Agency for Safety and Health at Work (European Agency for Safety and Health at Work 2005). No other changes to the participants' workstations or chairs were made.

Informed signed consent was obtained from each eligible participant in the study by the researcher after they agreed to participate in the study.

### **Description of the intervention and control chairs**

The similarities and differences between the chairs are illustrated in Table 1.

Figure 1 shows photographs of the participants' own chairs. For the study, all labelling was removed from the ergonomic chairs to ensure blinding of the participant as to which chair was the control and intervention ergonomic chair.

### **Ergonomic chair intervention**

For *Phase B* and *Phase C*, the ergonomic chairs were to be set up by the researcher according to training received by the intervention ergonomic chair manufacturer. The chair height was set up such that the participant's elbows were in line with the desk; the arm rest height such that the elbows were supported on the rests whilst sitting in the chair and were

at the same height as the keyboard; the back rest position was set up between 100° and 110°, and the participant's feet had to touch the floor or be on a foot rest. This is in accordance with the guidelines set out by the European Agency for Safety and Health at Work (European Agency for Safety and Health at Work 2005). Identical information regarding the features of the intervention and control chairs was given to each participant according to the training received by the researchers. The participants were shown how to adjust the back support from a fixed to a mobile position and the height of the chair to allow for the correct arm height. For the intervention chair, the participants also received instruction on how to adjust the arm rests according to elbow height or chair position. No ergonomic training regarding posture; workstation setup; or work changes was given.

### **Selected outcome measures**

The primary outcome measures were Visual Analogue Scales (VAS). There were a total of four VAS scores: muscle tension intensity; muscle tension frequency; pain intensity; and pain frequency.

For VAS outcomes, reliability and validity have been established (Gajasinghe, Wijayarathna & Abayadeera 2010, Hawker et al. 2011). The minimal clinically important difference (MCID) has been shown for chronic conditions, such as rheumatoid arthritis and rotator cuff disease to be between 11 and 13.7 points out of one hundred. (Hawker et al. 2011)

The two secondary outcome measures were the Neck Disability Index (NDI) as a measure of disability and the Work Productivity and Activity Impairment health questionnaire (WPAI) as a measure of productivity.

For NDI, validity and reliability for chronic neck pain has been established (Gay, Madson & Cieslak 2007, Pietrobon et al. 2002). The MCID has been shown to be seven points out of 50 (Cleland et al. 2006).

The WPAI has been shown to have both construct validity and reliability (Reilly et al. 2010). MCID has not been established for neck pain.

### **Measurement time frames and method of outcomes**

For all phases, the four VAS scores were

administered twice a week on a Tuesday and Friday afternoon between 2p.m. and 3p.m. The NDI and WPAI were administered once a week on a Friday afternoon together with the VAS outcomes.

All outcomes were administered electronically and returned to the researchers via email. The outcomes were printed and the results entered manually and compiled onto a Microsoft Excel 2010 spread sheet. Unfortunately, due to limitations, the researcher was not blinded as to which chair the participant received.

### **End of phase and exit questionnaires**

An end of phase email, with specific questions regarding symptoms, medication usage and chair usage and changes during the four week phase, was sent on the last day of each phase. An exit email questionnaire was sent at the end of the entire study. The questions asked the participant whether there had been any stressful event during the study, if there had been any injuries sustained and whether the participant had changed medication throughout the 20 weeks. Subjects were requested to give any relevant information, such as a change in exercise routine, which may have influenced the results.

### **Data analysis**

All data was captured on a Microsoft Excel 2010 spread sheet and the mean calculated for each phase of each outcome. The range was calculated as a measure of variance for each outcome. For the primary outcomes of all four VAS scales, line graphs were constructed to illustrate the mean, with error bars indicating the range.

## **RESULTS**

### **Participant description:**

Table 2 shows the main findings for the two participants. Both participants do high volume VDU work and have neck, shoulder and upper thoracic symptoms attributed to their work environment. Examination revealed that both participants had poor cervical motion control (tested with cranio-cervical flexion test (Falla, Jull & Hodges 2004)) as well as increased palpable muscle tone in the upper trapezius, scalene and levator scapulae muscles. Participant 1's chair had fixed arm rests and a fixed back rest and participant 2's chair had no armrests. There was no history of upper quadrant



Above left: Figure 1a. Above right: Figure 1b  
Figure 1: Photographs of chairs used in the study; 1a-Participant 1's own chair; 1b-Participant 2's own chair.

injury or disease for either participant.

Both participant 1 and participant 2 had lower than expected initial VAS scores. In the subjective assessments at the beginning of the interview process, participant 1 rated her pain according to the numeric pain scale (NPS) at a minimum of 5/10, however her initial VAS showed only a 10/100 pain intensity, not the expected 50/100. Participant 2's NPS at assessment was 6/10 however her initial pain intensity VAS was 16/100 and not the expected 60/100.

### Visual analogue scales (VAS):

Table 3 shows the means and ranges for all phases for all outcomes.

The trend of the data for participant 1 shows only a slight reduction in the mean for all VAS outcomes. The change to the mean scores over the course of the study is below 5/100 for all outcomes.

The reduction in the mean from the baseline to subsequent phases is significantly greater for participant 2. However, similar to participant 1, the means for the subsequent phases remains lower than phase 1.

Both participants' results show a similar trend towards a reduction in variance or range of symptoms with both the control and intervention chairs as shown by the values in Table 3 and graphs in Figure 2 and figure 3.

Standard deviation (SD) was calculated for four VAS, however, as the variance was so large, that the -2SD value was in the negative which is not plausible for a VAS as its lowest value is 0.

### Neck Disability Index (NDI):

As shown in Table 3, the NDI values for participant 1 were very low. The values for participant 2 were higher in the baseline phase and reduced to between

1.25/50 and 0.5/50 in the intervention phases.

### Work Productivity and Activity Impairment health questionnaire (WPAI):

For participant 1, all WPAI values were 0, and thus no data analysis could be performed.

Participant 2 showed a reduction in the percentage that the symptoms affected her productivity from 40% in the baseline phase to 7.5% in Phase B and 5% in phase C.

### End of phase and exit emails:

Table 4 and table 5 represent the data from the end of phase and exit emails. Participant 1 stopped using the control chair in the final 2 days of Phase C due to lower back pain which she attributed to the chair. This also resulted in visits to her general practitioner and physiotherapist for treatment and medication for the resultant lower back pain.

Participant 1 noted that her only change during the study was to start pilates in the final phase of the study.

Participant 2 noted an increase in general stress levels due to personal circumstances as well as an increase in work load. She also started pilates and running during the baseline phase of the study.

Table 2: Participant description

Participant	Age (yrs)	Current work (years)	VDU hours/day	Symptom duration	Area of pain	Aggravating factors	Easing factors	Physical examination findings	Work station findings	OMPQ (<105) and red flags
1	50	Stock broker (4yrs 9m)	9hrs	10 yrs	A1- Neck and headache Constant 5/10 to 8/10 A2- Upper thoracic and shoulders Intermittent 7/10	A1- neck movements A2- long duration sitting A1 and A2 – stress at work and increased work load	Heat Traumeel© Physiotherapy Movement and light exercise	Forward Head Posture and ↓ Tx kyphosis ↓Cx side flexion ROM ↓Motor control Cx flexion ↓ tone UT, scalenes & LS	No footrest Arm rests not adjustable	OMPQ score 64 (low risk) No red flags
2	29	Data capturer (3yrs 3m)	7-8hrs	2yrs 6m	A1- bilat upper trapezius area and posterior neck Intermittent 8/10 A2- Upper thoracic and between scapulae Intermittent 6/10	A1- increased work load A1 and A2- long duration sitting, increased stress at work	Massage NSAID's and pain medication A2- eased with movement	Forward Head Posture and ↓ Tx kyphosis Ipsilateral A1 at end of Cx rotation ↓ motor control Cx extension ↑ tone UT, scalenes & LS	No armrests	OMPQ score 98 (low risk) Dizziness caused by low blood sugar

Cx – cervical spine; Tx- thoracic spine; UT-upper trapezius; LS-levator scapulae; OMPQ- Orebro Musculoskeletal Pain Questionnaire

**Table 3: Study results per phase for both participants**

Study phase	A1	B	A2	C	A3
Outcome measure	Range (mm) Mean (SD)	Range (mm) Mean (SD)	Range (mm) Mean (SD)	Range (mm) Mean (SD)	Range (mm) Mean (SD)
Pain: Frequency (VAFS) (/100)					
Participant 1	18 (5-23) 12.125 (5.06)	9 (6-15) 9.333 (3.14)	3 (7-10) 9 (1.29)	6 (5-11) 8.857 (2.04)	4 (6-10) 9 (1.60)
Participant 2	49 (19-68) 42.5 (21.39)	12 (3-15) 5.75 (4.89)	2 (3-5) 3.5 (0.93)	7 (0-7) 1.625 (2.56)	4 (0-4) 0.88 (1.64)
Pain: Intensity (VAIS) (/100)					
Participant 1	21 (7-28) 11.63 (7.95)	15 (6-21) 9.33 (6.06)	5 (6-11) 8.26 (1.70)	5 (5-10) 7.17 (2.23)	7 (4-11) 7.13 (2.1)
Participant 2	51 (16-67) 36 (18.99)	7 (3-10) 4.75 (3.54)	2 (3-5) 3.25 (0.71)	9 (0-9) 1.88 (3.18)	7 (0-7) 1.5 (2.83)
Muscle tension: Frequency (VAFS) (/100)					
Participant 1	23 (10-33) 14.13 (8.24)	10 (9-19) 11.33 (3.83)	7 (8-15) 10.29 (2.29)	4 (8-11) 9.71 (1.11)	8 (7-15) 10.38 (2.33)
Participant 2	52 (18-70) 45.25 (19.69)	25 (0-25) 7.5 (8.21)	7 (3-10) 4.38 (2.45)	8 (0-8) 1.75 (2.87)	11 (0-11) 3.38 (4.78)
Muscle Tension: Intensity (VAIS) (/100)					
Participant 1	25 (8-33) 12.13 (8.74)	9 (6-15) 9.67 (4.03)	6 (7-13) 9 (2.45)	4 (4-10) 7.71 (1.8)	4 (7-11) 8.38 (1.51)
Participant 2	50 (19-58) 38.88 (18.28)	19 (0-19) 5.25 (6.25)	5 (0-5) 3.13 (1.55)	9 (0-9) 1.88 (3.18)	9 (0-9) 2.29 (4.02)
NDI (/50)					
Participant 1	2 (1-3) 2 (0.82)	1 (2-3) 2.67 (0.56)	1 (2-3) 2.67 (0.56)	0 (3) 3 (0)	0 (3) 3 (0)
Participant 2	11 (8-19) 12.5 (5.45)	2 (0-2) 1.250 (0.98)	4 (0-4) 2 (1.83)	2 (0-2) 0.5 (1)	2 (0-2) 1 (0.82)
WPAI					
Participant 1	0	0	0	0	0
Participant 2	40 (20-60)	20 (0-20)	10 (0-10)	10 (0-10)	0
(expressed as a percentage)	40 (18.257)	7.5 (9.574)	2.5 (5)	5 (5.773)	0

## DISCUSSION

Ergonomic adaptations are a common workplace intervention to reduce upper quadrant musculoskeletal symptoms (Anderson 2006). This is the first study to report whether an ergonomic office chair, irrespective of arm rest adjustability, could have an effect on pain, muscle tension, productivity and disability. The findings of this single subject design study illustrated an immediate reduction in the intensity and variance of the symptoms following the introduction of the ergonomic chair, irrespective of which chair was allocated for the first intervention phase. Two strengths of this study were the random allocation of the chairs and that the participants were unaware of the cost of each chair as well as which of the chairs was the control or intervention. This contributes towards the validity of the study outcomes.

The findings illustrated a reduction in both frequency and intensity of self-

reported pain and muscle spasm. This research is consistent with the results of Amick et al (2003) and Robertson et al (2009). However their interventions included specific posture and office setup ergonomic training together with the ergonomic chair.

The underlying mechanism of this positive change in symptoms remains debatable. One probable explanation is that there was a change in relative postural alignment of the neck, thoracic spine and upper limbs. In this study, we specifically ensured that the elbows were positioned in such a manner that they were supported on the arm rests at the same height as the keyboard. The use of a footrest ensured that the height of the chair could be correct according to the desk height while the participant's feet remained supported. Previous research has indicated that adjusting the elbow position in this manner reduces strain on the upper quadrant joints and mus-

cles (Marcus et al. 2002). The corrected elbow angle, and head-on-neck position discourages extreme postural angles which are associated with sitting-related pain (Prins 2008).

In this study, the participants did not receive any education regarding postural alignment or sitting behaviour. The participants were informed of the features of the chairs and as such could adjust them according to their own comfort and discretion (Amick III et al. 2003, Robertson et al. 2009). As neck and upper quadrant sitting positions vary in symptomatic as well as asymptomatic subjects (Szeto, Straker & Raine 2002, Szeto, Straker & O'Sullivan 2005), it may be that it is important for physiotherapists to empower clients on how to adjust their own chairs rather than implementing strategies which are aimed at teaching uniform posture. Prolonged static postures have been shown as a contributing factor to the development of UQWMSD

**Table 4: Results of the end of phase emails for Participant 1**

Phases	Medication (pain/spasm)	Healthcare consultation	% time in chair	Chair adjustments
A1	No	Yes – osteopath for leg injury	100%	Yes – raised
B – Intervention chair	No	Yes – osteopath for leg injury	100%	Yes – lowered
A2	No	No	100%	No
C – Control chair	Yes - Celebrex	Yes – GP and physio for LBP	90% - stopped due to LBP	No – but stopped using chair
A3	Yes- Celebrex	Yes – GP and physio for continued LBP	100%	No

**Table 5: Results of end of phase emails for Participant 2**

Phases	Medication (pain/spasm)	Healthcare consultation	% working time in chair	Chair adjustments
A1	No	No	90%	No
B – Control chair	No	No	90%	No
A2	No	No	70%	No
C – Intervention chair	Yes – menstrual pain	No	80%	No
A3	Yes – menstrual pain	No	80%	No

(Griffiths, Mackey & Adamson 2007), educating a client to adjust their sitting position occasionally may reduce this risk. This may also explain why the symptoms were not exacerbated during the washout and final phases of this study since participants indicated that they adjusted their own office chairs.

The changes to the mean and variance of the outcomes in the first intervention phase are maintained throughout the rest of the study phases, including the washout A2 and final A3 phases. There appears to be a break in the chronic pain and muscle spasm cycle following the

first intervention phase. This change is irrespective of which ergonomic chair the participants were given. A similar effect on the pain cycle is suggested by Clark et al (2012) as a response to manual therapy where by the pain-spasm-pain cycle is disrupted by a physiotherapy intervention (Clark et al. 2012). This may explain the maintenance of symptom reduction throughout the washout phases of this study. Similar results of prolonged effect of an ergonomic intervention were shown in an International study by Dainoff et al. 2005 where the improvements were still present at one year follow up for

the majority of the participants (Dainoff, Cohen & Dainoff 2005).

As the footstool was introduced for Participant 1 from the start of the study, it may be the cause of the low scoring of the VAS from the beginning of the baseline phase A1. In the subjective assessment, Participant 1 claimed that her pain was 5/10. However, her baseline mean was lower from the start. As the change in the chair was shown to be almost immediate, it is possible that the introduction of the footstool improved Participant 1's outcomes immediately too. The footstool would have altered Participant 1's sitting

**Figure 2: Graphs depicting mean values for VAS outcomes for Participant 1 showing variability of data for each phase**

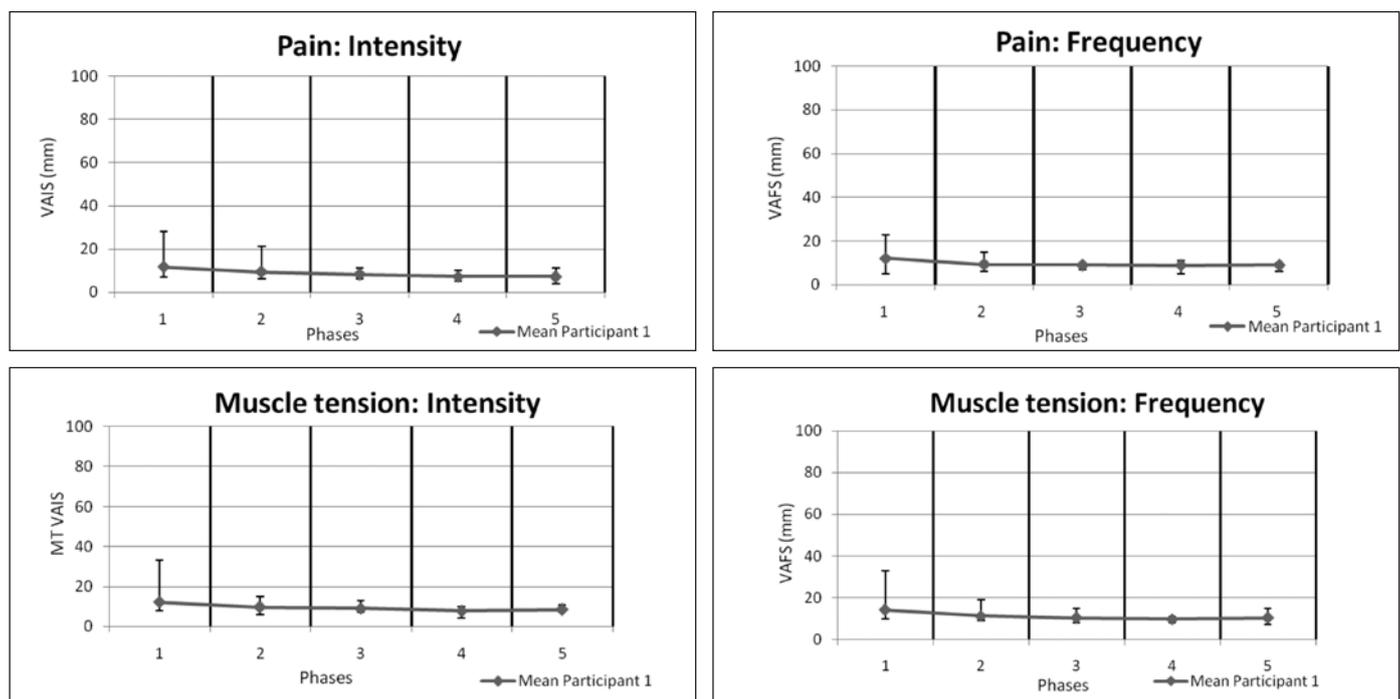
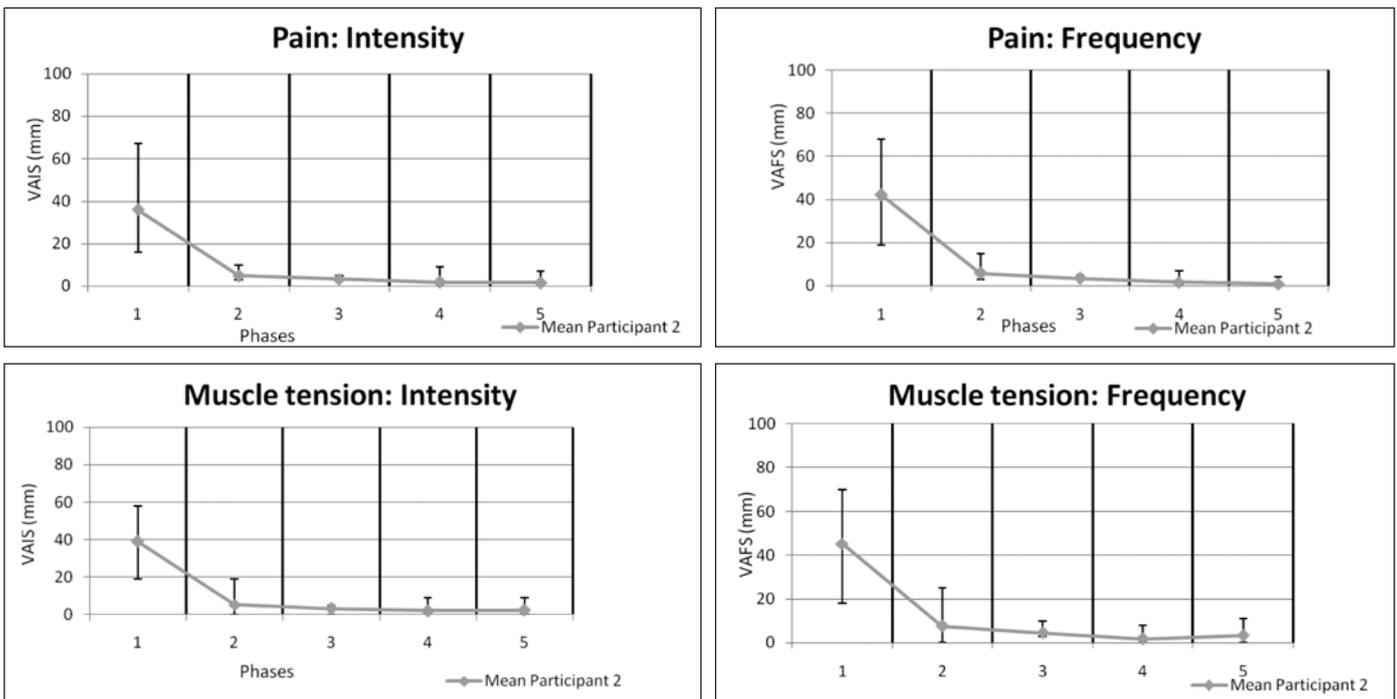


Figure 3: Graph depicting mean values for VAS outcomes for Participant 2 showing variability of data for each phase



position and thus her upper quadrant posture and muscle activity. Further research into the effect of providing only a footstool is required to analyse this effect.

Participant 2 showed a reduction in both mean and variability following the first intervention phase. These results may have been more prominent when compared to participant 1's results as participant 2's own/original chair was more basic. It lacked arm rests and had a lower back rest compared to the ergonomic chairs provided for the study and when compared to participant 1's own chair (figure 1a and figure 1b). Participant 1's chair was similar to the intervention chairs, but lacked full adjustability. The effect of arm rests on pain and symptoms has been shown in the review by Kennedy et al (2010) to have a positive influence on upper quadrant pain and symptoms. However, not all studies on the subject concur as some studies show no effect (Brewer et al. 2006).

Economic cost of an ergonomic chair is an important consideration when planning a computer work station intervention. This research illustrates that the lower cost chair may be adequate to improve musculoskeletal symptoms in the short term. The change in productivity shown by participant 2 may help encourage employees and companies to invest in improved ergonomic office equipment with the minimal requirements of lumbar and height adjustability as well as footrests. The review by Tompa et al (2010) had similar sugges-

tions. However it acknowledged that the research is of only moderate strength. Brewer et al also noted that, although ergonomic chairs have been shown with moderate evidence to be beneficial, the feature of arm rest adjustability has not been shown to be definitively beneficial (Brewer et al. 2006). The improvement in the disability shows the benefit at an individual level for the client or employee to invest in their own office equipment. The findings illustrated that the added benefit of adjustable arm rests may be small. However caution must be applied as this study did not aim to assess durability or long term effects to estimate cost effectiveness.

#### Limitations and recommendations:

This study had only two participants and larger studies are needed before the results can be generalised. The washout phase may need to be lengthened to the point where the subject's outcomes return to that of the baseline phase. This will make the comparison of the intervention phases more obvious.

Blinding of the researcher as to which chair was provided during the intervention phases would have added to the quality of the study.

The Hawthorne effect (Adair 1984), which is the alteration of behaviour by the subjects of a study because they are being observed, may have had an effect in this study. However, as the symptoms did

not return during the washout phase, it is less likely that the subconscious effect of using a new chair was the main cause of the change in outcomes. This study only researched the effect of the chair on upper quadrant symptoms and research into the effect of pain in other areas is warranted.

Future studies into prevention of work-related musculoskeletal dysfunction should also be conducted.

#### CONCLUSION

The aim of this study was to ascertain the effect of a fully adjustable computer workstation chair compared to a chair with limited adjustability (armrests not adjustable) on sitting-related upper quadrant pain, muscle spasm, disability in female office workers. The findings of this series of single subject (N=2) study illustrated that both intervention chairs reduced the intensity, frequency and variability of pain and muscle spasm. This implies that office chairs without adjustable armrests may be equivalent to more expensive fully adjustable chairs with respect to pain, muscle spasm and disability. Further research with larger population studies and longer follow-up time frames is now required to affirm these findings in a representative sample.

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